POWER

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Get a Hobby

BY JAMES FRANCIS JONES

THIS WAS THE FIRST HOBBY, TRY IT AGAIN IT'S CHEAPER THAN AN AUTO

SOME YEARS AGO a man in England gave a thousand pounds to be used to aid artisans in finding hobbies, or pleasing diversions, as one might say, for leisure hours.

There is ample moral and educational ground to justify such a gift. Leisure time amounts to a social problem. It concerns the school, the church and the state. It involves both the young and the old. Unprofitable leisure conduces to intellectual and moral backsliding. So thoroughly established is this fact that some educational authorities advocate an all-the-year-round school period in place of a nine months' school year, in the belief that the long summer vacation is inimical to the well-being of the child. Penology has long recognized the evil effects upon convicts of prolonged periods of idleness.

A HEALTHFUL HOBBY

CHESS, AN INTELLECTUAL HOBBY

WITH industrial development hours of labor shorten and hours of leisure lengthen. It is a familiar argument against the eight-hour day that the added hours of leisure are a menace to the workingman and the community because spent in idle, if not evil, ways. Fortunate is the individual who, when the engrossing cares of life are sidetracked for a season, finds himself responding to the alluring call of a legitimate hobby.

The value of a hobby lies chiefly in the fact that it is a creator of interest. Interest makes life worth while. A good hobby prolongs life. It is said all long-lived persons have had hobbies. Gladstone's was swinging the ax and reading Greek. Grover Cleveland's and Joe Jefferson's was fishing. Sir James Bryce is a mountain climbing hobbyist. Andrew Carnegie has made a hobby of giving away libraries.

There are multitudes of hobbies. They are as numerous and variant as the stars. There are collecting hobbyists—collectors of postage stamps, rare books, objects of art, precious stones; animal fanciers, who make a hobby of dogs, cats, birds or horses; outdoor-life hobbyists, who are enamored of hunting, fishing, boating, or gardening; health hobbyists, devotees of certain physical exercises, fresh air, diet and sleep.

LOUIS XVI, OF FRANCE, was never quite so happy as when tinkering with locks and keys. Nero fancied himself a poet and fiddler. Charles V, of Spain, had a passion for synchronizing timepieces.

Charles Dickens tells an amusing story of a man who had a mania for collecting clocks. He glutted his house with them, and kept them all running. But they did not keep the same time, and throughout all the hours of the day and night one or another of them was striking or chiming. The wife was distracted and could endure it no longer. Nevertheless, the husband resolved after long consideration that he could not part with his clocks. A separation followed, but later a compromise was reached which provided that the husband should keep his clocks, but they were to be allowed to run down and were never to be wound by him again.

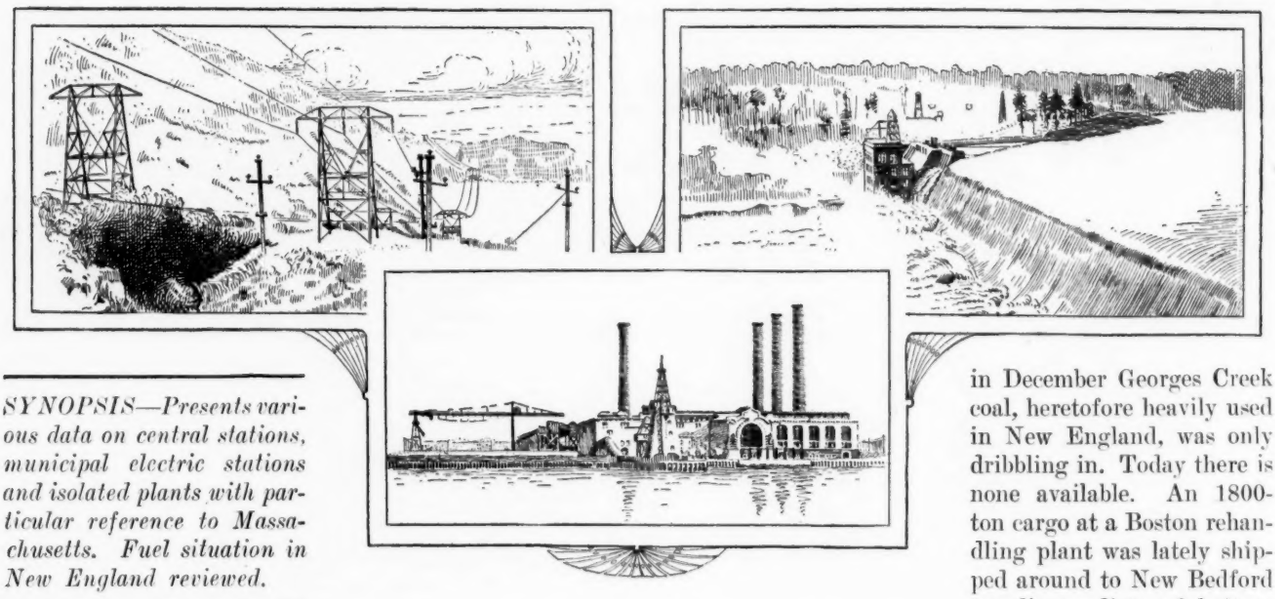
Common sense is required for the selection and gratification of even a hobby. The walking hobby would not prove mentally or physically the most suitable diversion for a letter carrier or a farmer, though for a person leading a sedentary life, time could not be better employed.

PERPETUAL MOTION A MISDIRECTED HOBBY

DIGGING FOR CAPTAIN KID'S TREASURE, SOME HAVE EVEN BEEN OBSESSED WITH THIS HOBBY

Some Aspects of the Power Situation in New England

By Charles H. Bromley



SYNOPSIS—Presents various data on central stations, municipal electric stations and isolated plants with particular reference to Massachusetts. Fuel situation in New England reviewed.

On April fifth, and possibly the sixth, the Boston Section of the American Society of Mechanical Engineers will meet at the Engineers' Club, Boston, for the purpose of discussing central stations, municipal electric stations and isolated plants. The purpose of this article is to make available information, data and suggestions that not only should help expedite discussion, but will interest readers generally in other parts of the country.

Because fuel costs amount usually to from 55 to 70 per cent. of the total cost of power production; because of the shortage of coal and its high price in New England; and further, because of the competition that coal meets and will continue to meet from fuel oil in that locality, the fuel situation must be considered in any discussion of power costs.

It is very difficult to get coal in New England today. To cite two illuminating cases: The plant of the Rhode Island Co. at Providence had such poor fuel on its grates recently that the difficulty of keeping up steam with it caused a block of the street-railway traffic. A Boston coal contractor was lately offered several thousand tons of New River and Pocahontas coal, at $4 per ton Newport News, with $3 per ton as the freight rate to Boston, and he was not given long to decide whether he would take it or not.

Some, though as yet not many, isolated plants have found it necessary to buy central-station current because of the unavailability of coal and its high price. The Edison Electric Illuminating Co. of Boston is not encouraging its salesmen in the acceptance of such business except where no appreciable investment is required by that company to furnish the current. Where the investment is appreciable, the business is not accepted.

Table I shows the trend of coal prices in New England from two years prior to the war to the time of going to press. Think of $15 a ton alongside, Boston and Providence, for New River and even for Clearfield coals! Early in December Georges Creek coal, heretofore heavily used in New England, was only dribbling in. Today there is none available. An 1800-ton cargo at a Boston rehandling plant was lately shipped around to New Bedford to relieve a distressful situation there. Eastern Massachusetts is being searched for anthracite screenings for Boston hotels and other city buildings, many of which have been compelled to use soft coal in unsuitable furnaces. A much greater than usual quantity of smoke in Boston is evidence of this condition. Early in January shippers of Pennsylvania coals withdrew their prices and at this late day show no inclination to reopen them at the old figures, but demand much higher ones. Many shippers are not seeking business, because of labor trouble, car shortage and congestion. Prices as high as $7.50 per ton f.o.b. the mines have been offered for Pennsylvania coals. Next season's business, beginning Apr. 1, is being canvassed on the basis of freight rates Hampton Roads, of $2 to Providence and $2.50 to Boston. Though many shippers are much behind on contract deliveries, they are being importuned to accept new business. To make the situation worse, the continued cold in New England during the winter has caused the consumption of most mills to be astonishingly higher than for like periods last year.

Shippers who have their own bottoms are reluctant to accept new business delivered alongside, Providence, Boston and Portland, preferring to realize the very high rates available if they put their vessels in foreign shipping service.

With the coal situation thus, one naturally wants to know what is the outlook for oil fuel. Here is the situation: First, none of the oil companies is at this writing seeking business or making contracts. The supply of bottoms is now inadequate, or just adequate, and the Navy Department may at any time commandeer ships in the oil-carrying trade. Shipyards where many are now being built for the trade also may be commandeered and thrown off the ways for the accommodation of other more important craft.

The three companies most heavily engaged in the fuel-oil business in New England are the Mexican Petroleum

Corporation, the Standard Oil Co. and the Gulf Refining Co. The first handles nothing but fuel oil, while the others sell distillates too.

It is not proposed here to consider the factors that should influence one's judgment when considering changing from coal to oil, as these were covered by the writer in *Power* for Dec. 19, 1916, page 852.

The Mexican Petroleum Corporation is making large investments in New England, and certainly is, and will more and more become, a keen competitor for steam-plant fuel with the various coal interests. The price of oil then must always compete with coal if anything is to be realized on these investments.

This company is the only one, so far as the writer knows, that is making all long-term contracts, these being nearly all for five years, with a few for three. As to continuity of supply, the fields are estimated to be able to furnish 75,000,000 bbl. per year for from 25 to 30 years. One well is now giving 265,000 bbl. a day. Eight tank steamers are in service and 20 are building, each having a capacity of about 50,000 bbl. All oil comes via Tampico. The aim is to provide storage for 15,000,000 bbl. in the United States, which will give from three to four months' storage in the event of serious Mexican internal trouble. Although Mexico had been much disturbed for over four years, failure of delivery of oil to an American consumer has not occurred. In New England the company's storage capacity is as follows: Portland, Me., four 55,000-bbl. tanks; Boston, complete May 1, 1917, four 55,000-bbl. tanks with three more of like capacity going up later at Chelsea; Providence will soon have a total of four 55,000-bbl. and one 37,500-bbl. tank, with room for four more 55,000-bbl. tanks; New York City has eight 55,000-bbl. tanks.

The Gulf Refining Co. has lately enlarged its station at East Providence, and the Standard has recently purchased 60 acres in the same city for storage purposes. Part of the storage capacity of these two companies will be used for fuel oil. Mexican fuel oil has increased in price roughly 60 per cent. since the war began, selling at that time on five-year contracts for 90c. per bbl. of 42 gal. at 60 deg.; now it is bringing $1.50 with little or no chance of getting the shippers to accept the business.

TABLE I. ADVANCE IN COAL PRICES IN NEW ENGLAND

New River and Pocahontas Coals

Date	F. O. B. Hampton Roads	On Cars		Freight Rates per Ton Hampton Roads to Boston
		Boston	Providence	
Jan. 27, 1912.....	$2.70	$4.20-4.35	$4.10-4.35	$1.00-1.10
Feb. 17, 1912.....	2.70-2.85	4.50-4.75	4.35-4.50	1.25
Jan. 18, 1913.....	3.50-3.60	4.53-4.75	4.50-4.75	80c.
Feb. 22, 1913.....	2.70-2.80	3.85-4.10	.....	95c.-$1.00
May 10, 1913.....	2.75-2.85	3.73-3.90	3.73-3.78	70c.-75c.
Aug. 2, 1913.....	2.85-3.10	4.05-4.15	3.95-4.10	.....
Jan. 10, 1914.....	2.80-2.90	3.72-3.82	3.72-3.78	70c.-75c.
Feb. 14, 1914.....	2.80-2.85	3.58-3.65	3.58-3.68	70c.-75c.
May 2, 1914.....	2.80-2.85	3.60-3.78	3.55-3.73	65c.-70c.
May 23, 1914.....	2.80-2.85	3.40-3.70	3.50-3.78	55c.
June 13, 1914.....	2.80-2.85	3.35-3.63	3.40-3.68	65c.-75c.
Nov. 7, 1914.....	2.50-2.75	3.50-3.78	3.35-3.73	55c.-65c.
Dec. 26, 1914.....	2.55-2.75	3.50-3.73	3.35-3.63	70c.-80c.
Mar. 13, 1915.....	2.70-2.80	3.70-3.90	3.58-3.73	90c.-1.00
June 15, 1915.....	2.75-2.85	3.70-3.78	3.60-3.73	75c.
Nov. 27, 1915.....	2.80-2.85	3.65-3.83	3.63-3.78	1.10
Dec. 18, 1915.....	2.85	6.00-6.25	5.75-6.00	3.00
Jan. 15, 1916.....	2.85	6.75-7.00	6.75-7.00	3.25-3.50
Feb. 12, 1916.....	2.85	5.50-5.75	5.50-5.75	.....
May 20, 1916.....	2.80-2.85	5.15-5.35	5.15-5.35	.....
July 8, 1916.....	2.80-2.85	4.80-4.90	4.80-4.90	.....
Aug. 12, 1916.....	3.00-3.25	5.10-5.20	5.10-5.20	.....
Sept. 16, 1916.....	4.00 and up	6.50-6.75	6.50-6.75	2.00
Oct. 14, 1916.....	4.50	6.50-6.75	6.50-6.75	1.65-1.75
Nov. 11, 1916.....	5.50-7.00	8.50-9.00	8.50-9.00	2.00
Nov. 18, 1916.....	7.00-7.50	8.50-9.50	8.50-9.50	2.00
Dec. 2, 1916.....	.....	9.50-10.00	9.50-10.00	.....
Dec. 9, 1916.....	.....	9.50-10.00	9.50-10.00	.....
Jan. 6, 1917.....	7.00-7.50	9.25-9.75	.....	2.60 and up
Jan. 20, 1917.....	6.50-7.00	9.25-9.50	9.25-9.50	3.00 and up
Jan. 27, 1917.....	6.50-7.00	9.25-9.50	9.25-9.50	3.00 and up
Feb. 10, 1917.....	6.50-6.75	9.25-9.50	9.25-9.50	3.00 and up
Mar. 3, 1917.....	7.00-7.25	14.50-15.00	13.00-15.00	4.00 refused

The labor charge in large plants is considerably reduced by oil fuel. We get an idea of how appreciable the reduction in this charge is by taking one of the mills of the American Woolen Co. at Lawrence, Mass., as an example, though here the change from coal to oil was done

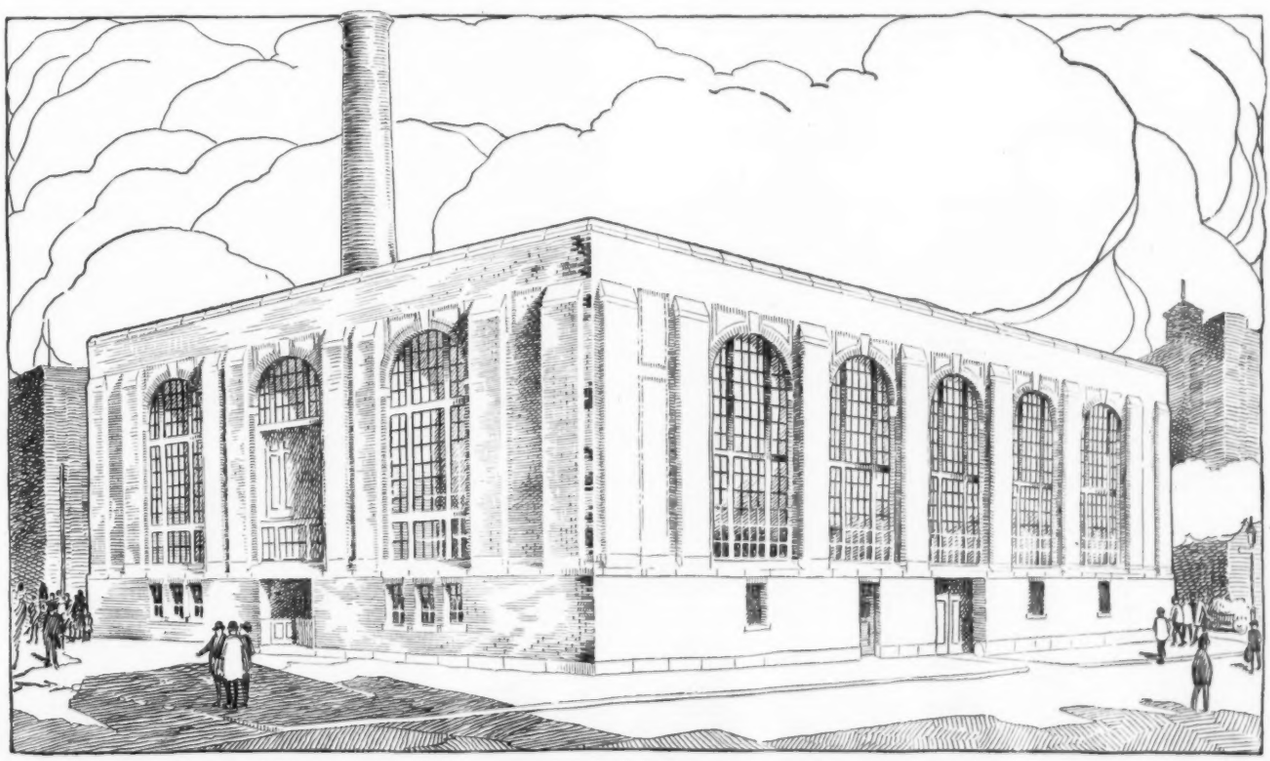


FIG. 1. POWER HOUSE FOR THE TAMARACK MILLS AND THE JENCKS SPINNING CO., PAWTUCKET, R. I.

to reduce the effectiveness of a bad labor situation in the fireroom. The plant has 15 water-tube boilers and employed a total of 63 firemen with coal; with oil there are but 7 men on the payroll for the same boiler-horsepower output.

Fig. 1 shows the new Tamarack power house for the Tamarack mills, Pawtucket, R. I. The engineers, Jencks & Ballou, Providence, have designed it for oil burning, no coal bunkers, storage, coal or ash-handling machinery, stokers or draft apparatus being provided. The station was built only after extensive investigation of the oil situation and tests with oil in the plant of the Jencks Spinning Co. (which mills will later receive their power from the Tamarack station) to determine whether oil would be more economical than coal and if it would be cheaper to buy power than to build the station and make it. The plant will be of 5000 kw. (rated) capacity—two 2500-kw. turbines. A five-year contract for the fuel oil was closed

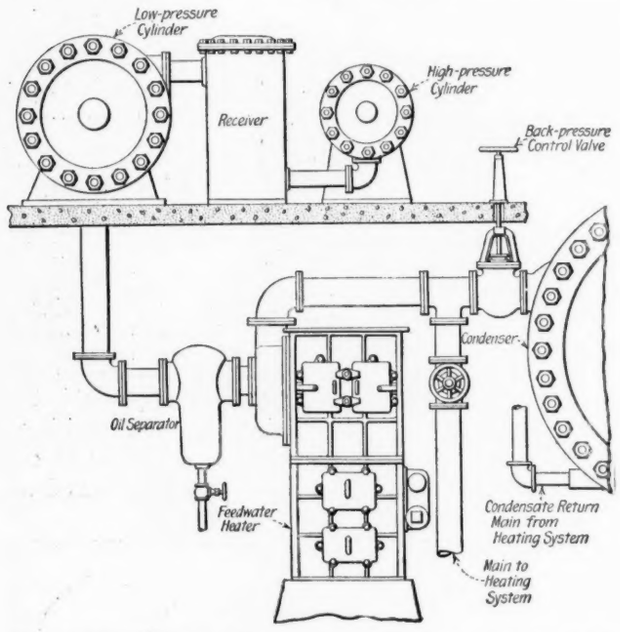


FIG. 2. LAYOUT OF EXHAUST PIPING AT LYNN REALTY CO.'S PLANT, LYNN, MASS.

at 90c. per bbl. of 42 gal. at 60 deg. F., delivered. The cost per kilowatt-hour, exclusive of the small amount of makeup water required, is 0.588c. and may be less in the new station.

Table II gives the coal costs per horsepower-hour and kilowatt-hour for different consumption rates and coal prices, the latter going about as high as most abnormal conditions will drive it.

Another unusually interesting mill plant is that of the Lynn Realty Co., Lynn, Mass., which furnishes light, heat and power to a group of three buildings having a total of 325,000 sq.ft. of floor area devoted chiefly to shoe manufacturing. One building is 200 x 50 ft., eight stories; one, 300 x 60 ft., eight stories; one 205 x 45 ft., two stories. All are of brick.

These buildings formerly used current purchased from the local electric company, but some years ago the owners installed their own plant. Considering that the installed capacity of the plant is only 400 kw., the saving effected by its performance over costs when purchasing current and supplying its own heat is indeed worthy of note. The conditions of operation do not vary much from year to year. Here are the chief results as shown by as many data as the writer was able to get:

Cost of lighting and heating buildings in 1909, current purchased, exclusive of overhead and minor supplies for the heating plant: Coal, $4151.80; labor, $1100; water, $171.33; current purchased, $10,025.75; total cost, $15,448.88.

Cost of furnishing light, heat and power in 1912 after power plant was installed, exclusive of overhead and minor supplies: Coal, $8464.38; labor, $2500; water, $534.76; total cost, $11,499.14; less income from current sold to tenants, $3309.62; total net cost, $8189.52.

Cost difference between purchased current and service supplied by the owner's plant: Cost of service with purchased current, $15,448.88; cost of service with owner's plant, $8189.52; difference, $7259.36.

Compromise Back Pressure Used

There is but one electric unit driven by a cross-compound engine; the unit is of 400 kw. capacity. A compromise back pressure is used and is responsible for much of the success of the heating system. The layout is shown diagrammatically in Fig. 2. Notice that the heating-system return main is connected to the condenser. In the summer and nonheating season the plant runs condensing. In the heating season the back pressure and steam to the heating system are varied as the heating requirements demand, by opening or closing the control valve shown. In the severest winter conditions not more than 1½ lb., gage, back pressure is needed. In mild weather it is from atmospheric to 10 in. vacuum; in summer 26 in. vacuum is carried. In winter weather live steam is turned on at about three o'clock in the morning and kept on until the engine is started at 7 a.m.

There are many plants that might adopt this system with very good results. The many advantages will become apparent with a little thought, lack of space preventing their mention here.

The plant affords an excellent citation in refutation of the much-used argument about unreliability of the independent plant. The engine, the only one in the plant, had been in service six years Mar. 1 last, and except for the week or two vacation and inventory shutdown each summer, it has been out of service during the working day but once, and this for but half an hour.

In Table III are given some performance figures from the plant of the largest and one of the most modern apartment houses in New York City. The writer is indebted to Arthur Vincent, superintendent and chief engineer, for the data.

The building is of brick and terra cotta, has a volume of 7,475,000 cu.ft. and 68,000 sq.ft. of radiation. All boiler, electric and refrigeration plant labor and half the superintendent's salary are included in the labor charge. The elevators are of the standard plunger type, and the refrigerating plant is of course indispensable. Considerable quantities of steam are required in such an establishment. The point is, that if current were purchased there would not be so great a reduction in labor required. The boilers are of the water-tube type, the engines high-speed angle-compound. The Cryor system of heating is employed. The costs given include the cost of heating the entire building and supplying steam to the laundry, etc. So much low-pressure steam is required that every piece

TABLE II. COAL COST IN CENTS PER HORSEPOWER-HOUR AND KILOWATT-HOUR AT VARIOUS PRICES PER TON.

Coal per Kw.-Hr., Lb.	Coal per I.Hp.-Hr., Combined Efficiency 90%, Lb.	Price of Coal per Ton of 2,000 Lb.																												
		$1.50	$2.00	$2.50	$3.00	$3.50	$4.00	$4.50	$5.00	$5.50	$6.00	$6.50	$7.00	$7.50	$8.00	$8.50	$9.00	$9.50	$10.00	$10.50	$11.00	$11.50	$12.00	$12.50	$13.00	$13.50	$14.00	$14.50	$15.00
1.0	0.67	0.0750	0.1000	0.1250	0.1500	0.1750	0.2000	0.2250	0.2500	0.2750	0.3000	0.3250	0.3500	0.3750	0.4000	0.4250	0.4500	0.4750	0.5000	0.5250	0.5500	0.5750	0.6000	0.6250	0.6500	0.6750	0.7000	0.7250	0.7500
1.1	0.74	0.0825	0.1100	0.1375	0.1650	0.1925	0.2200	0.2475	0.2750	0.3025	0.3300	0.3575	0.3850	0.4125	0.4400	0.4675	0.4950	0.5225	0.5500	0.5775	0.6050	0.6325	0.6600	0.6875	0.7150	0.7425	0.7700	0.7975	0.8250
1.2	0.81	0.0900	0.1200	0.1500	0.1800	0.2100	0.2400	0.2700	0.3000	0.3300	0.3600	0.3900	0.4200	0.4500	0.4800	0.5100	0.5400	0.5700	0.6000	0.6300	0.6600	0.6900	0.7200	0.7500	0.7800	0.8100	0.8400	0.8700	0.9000
1.3	0.87	0.0975	0.1300	0.1625	0.1950	0.2275	0.2600	0.2925	0.3250	0.3575	0.3900	0.4225	0.4550	0.4875	0.5200	0.5525	0.5850	0.6175	0.6500	0.6825	0.7150	0.7475	0.7800	0.8125	0.8450	0.8775	0.9100	0.9425	0.9750
1.4	0.94	0.1050	0.1400	0.1750	0.2100	0.2450	0.2800	0.3150	0.3500	0.3850	0.4200	0.4550	0.4900	0.5250	0.5600	0.5950	0.6300	0.6650	0.7000	0.7350	0.8250	0.8050	0.8400	0.8750	0.9100	0.9450	0.9800	1.0150	1.0500
1.5	1.01	0.1125	0.1500	0.1875	0.2250	0.2625	0.3000	0.3375	0.3750	0.4125	0.4500	0.4875	0.5250	0.5625	0.6000	0.6375	0.6750	0.7125	0.7500	0.7875	0.8800	0.8625	0.9000	0.9375	0.9750	1.0125	1.0500	1.0875	1.1250
1.6	1.07	0.1200	0.1600	0.2000	0.2400	0.2800	0.3200	0.3600	0.4000	0.4400	0.4800	0.5200	0.5600	0.6000	0.6400	0.6800	0.7200	0.7600	0.8000	0.8400	0.9350	0.9200	0.9600	1.0000	1.0400	1.0800	1.1200	1.1600	1.2000
1.7	1.14	0.1275	0.1700	0.2125	0.2550	0.2975	0.3400	0.3825	0.4250	0.4675	0.5100	0.5525	0.5950	0.6375	0.6800	0.7225	0.7650	0.8075	0.8500	0.8925	0.9900	0.9775	1.0200	1.0625	1.1050	1.1475	1.1900	1.2325	1.2750
1.8	1.21	0.1350	0.1800	0.2250	0.2700	0.3150	0.3600	0.4050	0.4500	0.4950	0.5400	0.5850	0.6300	0.6750	0.7200	0.7650	0.8100	0.8550	0.9000	0.9450	0.9500	1.0350	1.0800	1.1250	1.1700	1.2150	1.2600	1.3050	1.3500
1.9	1.27	0.1425	0.1900	0.2375	0.2850	0.3325	0.3800	0.4275	0.4750	0.5225	0.5700	0.6175	0.6650	0.7125	0.7600	0.8075	0.8550	0.9025	0.9500	0.9975	1.0450	1.0925	1.1400	1.1875	1.2350	1.2825	1.3300	1.3775	1.4250
2.0	1.34	0.1500	0.2000	0.2500	0.3000	0.3500	0.4000	0.4500	0.5000	0.5500	0.6000	0.6500	0.7000	0.7500	0.8000	0.8500	0.9000	0.9500	1.0000	1.0500	1.1000	1.1500	1.2000	1.2500	1.3000	1.3500	1.4000	1.4500	1.5000
2.1	1.41	0.1575	0.2100	0.2625	0.3150	0.3675	0.4200	0.4725	0.5250	0.5775	0.6300	0.6825	0.7350	0.7875	0.8400	0.8925	0.9450	0.9975	1.0500	1.1025	1.1550	1.2075	1.2600	1.3125	1.3650	1.4175	1.4700	1.5225	1.5750
2.2	1.48	0.1650	0.2200	0.2750	0.3300	0.3850	0.4400	0.4950	0.5500	0.6050	0.6600	0.7150	0.7700	0.8250	0.8800	0.9350	0.9900	1.0450	1.1000	1.1550	1.2100	1.2650	1.3200	1.3750	1.4300	1.4850	1.5400	1.5950	1.6500
2.3	1.54	0.1725	0.2300	0.2875	0.3450	0.4025	0.4600	0.5175	0.5750	0.6325	0.6900	0.7475	0.8050	0.8625	0.9200	0.9775	1.0350	1.0925	1.1500	1.2075	1.2650	1.3225	1.3800	1.4375	1.4950	1.5525	1.6100	1.6675	1.7250
2.4	1.61	0.1800	0.2400	0.3000	0.3600	0.4200	0.4800	0.5400	0.6000	0.6600	0.7200	0.7800	0.8400	0.9000	0.9600	1.0200	1.0800	1.1400	1.2000	1.2600	1.3200	1.3800	1.4400	1.5000	1.5600	1.6200	1.6800	1.7400	1.8000
2.5	1.68	0.1875	0.2500	0.3125	0.3750	0.4375	0.5000	0.5625	0.6250	0.6875	0.7500	0.8125	0.8750	0.9375	1.0000	1.0625	1.1250	1.1875	1.2500	1.3125	1.3750	1.4375	1.5000	1.5625	1.6250	1.6875	1.7500	1.8125	1.8750
2.6	1.74	0.1950	0.2600	0.3250	0.3900	0.4550	0.5200	0.5850	0.6500	0.7150	0.7800	0.8450	0.9100	0.9750	1.0400	1.1050	1.1700	1.2350	1.3000	1.3650	1.4300	1.4950	1.5600	1.6250	1.6900	1.7550	1.8200	1.8850	1.9500
2.7	1.81	0.2025	0.2700	0.3375	0.4050	0.4725	0.5400	0.6075	0.6750	0.7425	0.8100	0.8775	0.9450	1.0125	1.0800	1.1475	1.2150	1.2825	1.3500	1.4175	1.4850	1.5525	1.6200	1.6875	1.7550	1.8225	1.8900	1.9575	2.0250
2.8	1.88	0.2100	0.2800	0.3500	0.4200	0.4900	0.5600	0.6300	0.7000	0.7700	0.8400	0.9100	0.9800	1.0500	1.1200	1.1900	1.2600	1.3300	1.4000	1.4700	1.5400	1.6100	1.6800	1.7500	1.8200	1.8900	1.9600	2.0300	2.1000
2.9	1.95	0.2175	0.2900	0.3625	0.4350	0.5075	0.5800	0.6525	0.7250	0.7975	0.8700	0.9425	1.0150	1.0875	1.1600	1.2325	1.3050	1.3775	1.4500	1.5225	1.5950	1.6675	1.7400	1.8125	1.8850	1.9575	2.0300	2.1025	2.1750
3.0	2.01	0.2250	0.3000	0.3750	0.4500	0.5250	0.6000	0.6750	0.7500	0.8250	0.9000	0.9750	1.0500	1.1250	1.2000	1.2750	1.3500	1.4250	1.5000	1.5750	1.6500	1.7250	1.8000	1.8750	1.9500	2.0250	2.1000	2.1750	2.2500
3.1	2.08	0.2325	0.3100	0.3875	0.4650	0.5425	0.6200	0.6975	0.7750	0.8525	0.9300	1.0075	1.0850	1.1625	1.2400	1.3175	1.3950	1.4725	1.5500	1.6275	1.7050	1.7825	1.8600	1.9375	2.0150	2.0925	2.1700	2.2475	2.3250
3.2	2.15	0.2400	0.3200	0.4000	0.4800	0.5600	0.6400	0.7200	0.8000	0.8800	0.9600	1.0400	1.1200	1.2000	1.2800	1.3600	1.4400	1.5200	1.6000	1.6800	1.7600	1.8400	1.9200	2.0000	2.0800	2.1600	2.2400	2.3200	2.4000
3.3	2.21	0.2475	0.3300	0.4125	0.4950	0.5775	0.6600	0.7425	0.8250	0.9075	0.9900	1.0725	1.1550	1.2375	1.3200	1.4025	1.4850	1.5675	1.6500	1.7325	1.8150	1.8975	1.9800	2.0625	2.1450	2.2275	2.3100	2.3925	2.4750
3.4	2.28	0.2550	0.3400	0.4250	0.5100	0.5950	0.6800	0.7650	0.8500	0.9350	1.0200	1.1050	1.1900	1.2750	1.3600	1.4450	1.5300	1.6150	1.7000	1.7850	1.8700	1.9550	2.0400	2.1250	2.2100	2.2950	2.3800	2.4650	2.5500
3.5	2.35	0.2625	0.3500	0.4375	0.5250	0.6125	0.7000	0.7875	0.8750	0.9625	1.0500	1.1375	1.2250	1.3125	1.4000	1.4875	1.5750	1.6625	1.7500	1.8375	1.9250	2.0125	2.1000	2.1875	2.2750	2.3625	2.4500	2.5375	2.6250
3.6	2.42	0.2700	0.3600	0.4500	0.5400	0.6300	0.7200	0.8100	0.9000	0.9900	1.0800	1.1700	1.2600	1.3500	1.4400	1.5300	1.6200	1.7100	1.8000	1.8900	1.9800	2.0700	2.1600	2.2500	2.3400	2.4300	2.5200	2.6100	2.7000
3.7	2.48	0.2775	0.3700	0.4625	0.5550	0.6475	0.7400	0.8325	0.9250	1.0175	1.1100	1.2025	1.2950	1.3875	1.4800	1.5725	1.6650	1.7575	1.8500	1.9425	2.0350	2.1275	2.2200	2.3125	2.4050	2.4975	2.5900	2.6825	2.7750
3.8	2.55	0.2850	0.3800	0.4750	0.5700	0.6650	0.7600	0.8550	0.9500	1.0450	1.1400	1.2350	1.3300	1.4250	1.5200	1.6150	1.7100	1.8050	1.9000	1.9950	2.0900	2.1850	2.2800	2.3750	2.4700	2.5650	2.6600	2.7550	2.8500
3.9	2.62	0.2925	0.3900	0.4875	0.5850	0.6825	0.7800	0.8775	0.9750	1.0725	1.1700	1.2675	1.3650	1.4625	1.5600	1.6575	1.7550	1.8525	1.9500	2.0475	2.1450	2.2425	2.3400	2.4375	2.5350	2.6325	2.7300	2.8275	2.9250
4.0	2.68	0.3000	0.4000	0.5000	0.6000	0.7000	0.8000	0.9000	1.0250	1.1000	1.2000	1.3000	1.4000	1.5000	1.6000	1.7000	1.8000	1.9000	2.0000	2.1000	2.2000	2.3000	2.4000	2.5000	2.6000	2.7000	2.8000	2.9000	3.0000
4.1	2.75	0.3075	0.4100	0.5125	0.6150	0.7175	0.8200	0.9225	1.0500	1.1275	1.2300	1.3325	1.4350	1.5375	1.6400	1.7425	1.8450	1.9475	2.0500	2.1525	2.2550	2.3575	2.4600	2.5625	2.6650	2.7675	2.8700	2.9725	3.0750
4.2	2.82	0.3150	0.4200	0.5250	0.6300	0.7350	0.8400	0.9450	1.0750	1.1550	1.2600	1.3650	1.4700	1.5750	1.6800	1.7850	1.8900	1.9950	2.1000	2.2050	2.3100	2.4150	2.5200	2.6250	2.7300	2.8350	2.9400	3.0450	3.1500
4.3	2.89	0.3225	0.4300	0.5375	0.6450	0.7525	0.8600	0.9675	1.1000	1.1825	1.2900	1.3975	1.5050	1.6125	1.7200	1.8275	1.9350	2.0425	2.1500	2.2575	2.3650	2.4725	2.5800	2.6875	2.7950	2.9025	3.0100	3.1175	3.2250
4.4	2.95	0.3300	0.4400	0.5500	0.6600	0.7700	0.8800	0.9900	1.1250	1.2100	1.3200	1.4300	1.5400	1.6500	1.7600	1.8700	1.9800	2.0900	2.2000	2.3100	2.4200	2.5300	2.6400	2.7500	2.8600	2.9700	3.0800	3.1900	3.3000
4.5	3.02	0.3375	0.4500	0.5625	0.6750	0.7875	0.9000	1.0125	1.1500	1.2375	1.3500	1.4625	1.5750	1.6875	1.8000	1.9125	2.0250	2.1375	2.2500	2.3625	2.4750	2.5875	2.7000	2.8125	2.9250	3.0375	3.1500	3.2625	3.3750
4.6	3.09	0.3450	0.4600	0.5750	0.6900	0.8050	0.9200	1.0350	1.1750	1.2650	1.3800	1.4950	1.6100	1.7250	1.8400	1.9550	2.0700	2.1850	2.3000	2.4150	2.5300	2.6450	2.7600	2.8750	2.9900	3.1050	3.2200	3.3350	3.4500
4.7	3.15	0.3525	0.4700	0.5875	0.7050	0.8225	0.9400	1.0575	1.2000	1.2925	1.4100	1.5275	1.6450	1.7625	1.8800	1.9975	2.1150	2.2325	2.3500	2.4675	2.5850	2.7025	2.8200	2.9375	3.0550	3.1725	3.2900	3.4075	3.5250
4.8	3.22	0.3600	0.4800	0.6000	0.7200	0.8400	0.9600	1.0800	1.2250	1.3200	1.4400	1.5600	1.6800	1.8000	1.9200	2.0400	2.1600	2.2800	2.4000	2.5200	2.6400	2.7600	2.8800	3.0000	3.1200	3.2400	3.3600	3.4800	3.6000
4.9	3.29	0.3675	0.4900	0.6125	0.7350	0.8575	0.9800	1.1025	1.2500	1.3475	1.4700	1.5925	1.7150	1.8375	1.9600	2.0825	2.2050	2.3275	2.4500	2.5725	2.6950	2.8175	2.9400	3.0625	3.1850	3.3075	3.4300	3.5525	3.6750
5.0	3.36	0.3750	0.5000	0.6250	0.7500	0.8750	1.0000	1.1250	1.2750	1.3750	1.5000	1.6250	1.7500	1.8750	2.0000	2.1250	2.2500	2.3750	2.5000	2.6250	2.7500	2.8750	3.0000	3.1250	3.2500	3.3750	3.5000	3.6250	3.7500

of steam-using apparatus in the plant is virtually a reducing valve.

The engines consume 22.5 lb. of steam per kilowatt hour. (This is not the guarantee figure, which was lower.) In determining the unit costs this figure is used, 10 per cent. is taken as the loss in the engine (radiation, leakage, etc.), and 90 per cent. generator efficiency is used.

In a discussion of central stations, municipal electric stations and isolated plants, one naturally wants to know if the trend is toward higher rates. Up to this writing it is not. Many stations in Massachusetts reduced their rates, as shown in Table IV. The rates in Boston and other cities are too voluminous to publish here. While these maximum rates do not apply to consumers like industrial plants, where the consumption is usually great enough to get lower rates, they show the trend, it being impossible in the space here available to give the lower rates, of which there are many and which vary considerably.

The aggregate value of all electric companies selling power, exclusive of municipal plants, in Massachusetts, is $52,351,054. The Edison Electric Illuminating Co. of Boston is assessed on property value, locally, of $30,748,825.

Forty-three central-station companies paid out in dividends in 1915 the sum of $4,004,108.59, which is an average of 11.57 per cent. on their capital stock. This does not include water-power companies. The financial operations of incorporated companies and privately owned plants selling electricity show an apparent net profit for 1915 of $6,228,933.61.

The population supplied with electricity by corporations and privately owned plants selling current in 1915 was 3,375,850 according to the census of 1915. Hydro-electric plants are not included. Of this total the Edison Electric Illuminating Co. of Boston supplied 1,158,572.

The Edison Electric Illuminating Co. of Boston reported the following for 1916: The sales department contracted for 53,204 kw., an increase of 23.5 per cent. over the previous year. In 1916, the number of houses wired was 1816, compared with 1524 in 1915. The added connected load for 1916 was 28,287 kw., giving a total of 261,131 kw. for the system. In adding this load a total of 92,769 installation orders were handled. There was generated during the year 238,557,144 kw.-hr., an increase over 1915 of 14.5 per cent.

This includes 1,066,083 kw.-hr. from the Sudbury Dam. The maximum day's output was increased from 829,200 kw.-hr. to 990,982 kw.-hr. (Dec. 22). The coal used during 1916 was 238,578 short tons, or 13.9 per cent. more than in 1915.

If we subtract from 238,557,144, the total kilowatt-hours, the 1,066,083 kw.-hr. included but generated at Sudbury Dam, we have as the gross coal per kilowatt for the year, (238,578 × 2000) ÷ 237,491,061 = 2+.

Table V gives the reported cost per kilowatt-hour of the manufacture, purchase and distribution of current sold by central stations in Massachusetts for 1915.

From the standpoint of broad economics it is quite generally conceded that the block plant is desirable. The history of the block-plant movement, if it may properly

TABLE III. SOME POWER COSTS FROM A MODERN APARTMENT HOUSE

Original cost of plant on the foundation, 1909	$113,424
Present value at 10 per cent. charged off each year	60,279
Average Cost per 24 hr. for 1916:	
Labor	$39.59
Coal	54.13
Ashes	1.66
Oil	1.27
Supplies	7.01
Repairs	4.61
Improvements	.65
Depreciation (10% on $60,279)	16.51
Total cost per 24 hr	$125.43
Average cost per hr	5.22+
Quantities and Costs for Year Ended Dec. 31, 1916:	
Water consumed in boilers per 24 hr. (venturi-meter measured), lb.	376,911
Coal consumed per 24 hr., lb.	38,828
Ashes put out per 24 hr., lb.	6,538
Average horsepower-hr. developed per 24 hr	10,925.04
Average horsepower-hr. developed per hr	455.21
Water evaporated per pound of coal (actual conditions), lb.	9.271
Water evaporated per pound of coal (from and at 212), lb.	9.707
Coal (No. 3 Buck.) consumed per hp.-hr., lb.	3.55
Ash, per cent	16.8
Ash per analysis (commercial)	12.48+
Cost per hp.-hr., dollars	0.0114
Kw.-hr. delivered to board for 1916	788,129
Average kw.-hr. per 24 hr	2,159
Average kw.-hr. per hr	90
Electric load was 21% of total load and	
Cost per 24 hr., dollars	26.34
Cost per hr., dollars	1.10—
Cost per kilowatt-hour, dollars	0.012+
Income from store lighting per 24 hr., dollars	9.06
Net operating cost per 24 hr., dollars	116.37
Net operating cost per hr., dollars	4.85
Net hp.-hr. cost, dollars	0.0107
Net kw.-hr. cost, dollars	0.0114

Year	Average B. t. u.	Average Ash, per Cent.	Average Moisture per Cent.	Average Coal per Hp.-Hr., lb.	Average Coal Cost per Hp.-Hr., Dollars
1912	12,672.22	14.70	6.81	3.891 No. 1	0.0059
1913	12,538.46	14.687	7.05	4.427 Nos. 1, 2 & 3	0.0060
1914	12,826.43	14.425	6.386	3.487 No. 3	0.0051—
1915	12,825.01	13.57	6.75	3.329 No. 3	0.0043
1916	12,796.40	12.48	7.05	3.554 No. 3	0.0049+

be called a movement, is discouraging. Here briefly is its history in Boston. By block plant the writer means a plant serving a group of buildings such as city office buildings, and not any group of buildings such as those of schools, hospitals, mills, institutions, etc.

Years ago the New York Heat and Power Co. operated a block plant in the area bounded by Bedford, Summer and Chauncey Sts. The plant was in service many years when, after failure to negotiate with the owner Mr. Nichols, the Edison Electric Illuminating Co. is said to have got an option on a building in the block, the building separating the plant from most of the customers. The operators of the plant were forbidden to go through the property under option. Naturally, this condition forces the block-plant proprietor to compromise or perish.

There are really no block plants in Boston at present, nor is there likely to be. There was one in the Federal Court block bounded by Franklin, Federal High, Summer and Devonshire Sts., but the competition of the central-station company became so keen as to force a compromise with the proprietors of the block plant. The central-station company installs a master meter in the premises and makes the proprietors an attractive offer, the latter selling the service to the tenants, thus perpetuating the middleman clan.

This is the history of what is known as the Niles Building plant, which was put in to serve the block bounded by Washington, Court and Schools Sts., and City Hall Ave. Suppose that in thus putting the screws on the block-plant proprietors there are violations of the state

TABLE IV. REDUCTION OF MAXIMUM NET PRICE PER KW.-HR. FOR COMMERCIAL SERVICE

Massachusetts Central Stations, 1915*

Locality	Cost per Kw.-Hr., From	Cents To
Adams	13	12
Ayer	17	15
Cambridge	10	9
Edison (Brockton)	12	11
Lenox	16	15
Malden	11	10
Marion (in Bourne)	18	15
Marlborough	15	12
Milford	18	14
Nashua River	15.5	13.95
New Bedford	11.4	10.45
Mattapoinsett and Westport	16	13
North Adams	12.5	11
Suburban (Revere)	11	10
Williamstown	13	12
Worcester (in Leicester)	12	11
Worcester (Suburban)	15	14

* The 1915 Report of the Gas and Electric Commission is the latest available.

commission's rulings governing the actions of public-service electric companies. Such commissions rarely take the initiative, and the plant proprietors usually have not the funds to take their case before the commission.

There are six different companies dealing in hydro-electric power in Massachusetts: The Connecticut River Transmission Co. (operating in 24 cities), which gets its electricity from the Connecticut River Power Co.; the Central Massachusetts Power Co., operating in Palmer; the Franklin County Power Co., operating in two cities; the Holyoke Water Power Co. (a municipal proposition), operating in Holyoke and South Hadley; the New England Power Co., operating in two cities; and the Turners

TABLE V. COST OF CENTRAL-STATION CURRENT IN MASSACHUSETTS IN 1915

Company	Total Cost Manufacture, Purchase and Distribution per Kw.-Hr., Cents	Company	Total Cost Manufacture, Purchase and Distribution per Kw.-Hr., Cents
Cambridge	2.417	Lowell	3.089
Central Massachusetts	3.297	Lynn	3.156
Easthampton	0.935	Malden	3.887
Edison (Boston)	3.047	New Bedford	3.093
Edison (Brockton)	2.509	North Adams	2.064
Fall River	2.195	Pittsfield	3.425
Fitchburg *	2.068	Salem	2.943
Greenfield*	1.368	United (Springfield) *	2.108
Haverhill	3.113	Webster	2.189
Holyoke *†	1.592	Worcester	1.913
Lawrence *	3.765		

* Electricity generated partly from water power. † Municipal plant.

Falls Power and Electric Co., operating in eight cities. The Connecticut River Transmission Co. sold 125,351,717 kw.-hr. in 1915, which was nearly 80 per cent. of the whole amount sold by all companies and persons in the state for that year.

The total investment in municipal plants in Massachusetts to June, 1915, was as listed in Table VI.

Most of these municipal plants are paying investments, and from those conversant with the various methods of bookkeeping and auditing used by the respective municipalities, I learn that some of those now running at a loss, as shown on the books, would show a profit with the introduction of recognized correct accounting methods.

As to which kind of service is better—central station or independent plant—the local conditions must determine. Political economy dictates that the service which is the least costly in labor and resources is the one which will entail the least community loss, and should therefore be the one used. To permit a man to invest heavily in machinery for a plant which will be subjected to high peaks, yet have a very low load factor with little use for steam, as in many kinds of warehouse service (not refrigeration) for example; to permit him to operate such a plant at a loss, with its inevitable waste of the country's resources, is just as truly a community loss as a fire, a boiler explosion, a railway wreck or the smoke nuisance, and the public should be protected against it.

The problem, like nearly all problems of public electric and other similar service regulation, is an engineering one, which for its application (not solution) must have political expression.

Despite our wealth of natural resources, the woeful waste in the industries revealed by the conservation and efficiency activities of recent years must eventually force the state to take official cognizance of these wastes and enforce measures for their reduction. Just how far the state should go will of course remain a controversial question. It has long been regulating public-service corporations, and as an example of how searching are its inquiries into the affairs of such enterprises, and without commenting on the merits of the particular case, one finds the Massachusetts Gas and Electric Light Commission at a recent hearing on price arbitration for street lighting for Boston devoting a day to expert testimony to the effect that excess spare generating capacity had been installed at the L Street Station, the inference being that this unnecessary investment made electric rates higher than they should be.

TABLE VI. TOTAL INVESTMENT IN MUNICIPAL PLANTS IN MASSACHUSETTS TO JUNE 30, 1915

Ashburnham	$17,400	Middleborough	$176,316
Belmont	65,293	Middleton	6,793
Boylston	11,118	North Attleborough	136,309
Braintree	157,442	Norwood	71,552
Chicopee	314,941	Paxton	5,989
Danvers	166,520	Peabody	193,226
Georgetown	20,000	Princeton	15,734
Goroton	26,072	Reading	233,835
Groveland	17,850	Rowley	20,191
Hingham	63,918	Shrewsbury	43,869
Holden	20,498	South Hadley	40,000
Holyoke	2,227,062	Sterling	22,825
Hudson	99,520	Taunton	449,434
Hull	197,597	Templeton	33,435
Ipswich	77,511	Wakefield	277,661
Littleton	22,819	Wellesley	77,569
Lunenburg	16,000	West Boylston	28,053
Mansfield	110,389	Westfield	264,441
Marblehead	150,215		
Merrimac	23,076	Total	$5,902,473

While the community loss in a case such as the foregoing is direct, it is undeniable that it is just as truly a community loss for an individual or company to invest in a plant for temporary use—I refer to munition work, so much of which is being done in New England—when even half-informed engineering would dictate central-station service, especially when the plant is not permanent in character, but liable to sudden abandonment.

A discussion of this kind would be incomplete without an expression of regret that so many operating engineers little appreciate the necessity of not only getting the most out of their plants, but also recording the latters' performances. A goodly number of the isolated plants taken over by central stations have been shut down, not because the plant could not successfully compete with purchased power, but because indolent and incompetent operating management never seriously tried to make it do so.

Economies of Diesel-Engine Installation

The municipal electric light and power plant of the City of Palo Alto, Calif., presents an interesting example of the efficiency and economy to be effected with station installations designed with consideration for the particular character of service and local conditions. Not only has the station brought about a revenue increase through the reduction in current operating costs so as to be self-supporting, but has, within a period of three years, produced earnings to make possible a reimbursement for the first cost of the plant. The station represents an investment of about $80,400, with electric distributing system valued at $51,000.

The effectiveness of this municipal plant is credited, primarily, to the installation and operation of the Diesel unit, which has shown remarkable economy in fuel-oil consumption. Data covering the initial period of the operation of this engine (*Power*, May 2, 1916, p. 610) indicated unusual attainments, particularly in connection with fuel economy and upkeep, showing a production of more than 5 kw.-hr. per gal. of oil, with a fuel cost of operation of about two mills per kilowatt-hour under 24-hour service. The unit is of the Köerting type, rated at 450 hp., using California crude oil with an average specific gravity, at 15 deg. C., of 0.95 and heat value of 18,000 B.t.u. Installed in the fall of 1914, the engine was placed in actual service only for about one-half of the yearly period of 1914-15 ending in June, but since that time it has been operated without important interruption under 24-hour service to provide for the main load.

Interesting records of the operation of this municipal plant, compiled by J. F. Byxbee, Jr., city engineer, show an increase in the output of the station during the last year of 18.4 per cent. over the previous twelve months, representing a total production metered at the plant of 1,347,165 kw.-hr. The unit costs of power generation and distribution during this period are summarized as follows:

Fuel cost per kilowatt-hour	$0.0041
Total operating cost per kilowatt-hour (including fuel, wages, plant supplies, etc.)	.0102
Total plant cost per kilowatt-hour (including fuel, operation, interest and depreciation on plant)	.0153
Line maintenance per kilowatt-hour	.0051
Total distribution cost (including line maintenance, interest and depreciation on lines and services)	.0088
Office and accounting expense per kilowatt-hour	.0011
Total cost per kilowatt-hour	.0281

The plant output, 1,347,165 kw.-hr. as noted, has been utilized for the following services: Commercial connections, 783,534 kw.-hr.; street lighting, 78,741; pumping plant, 203,883; power plant, 15,657; garbage-destructor plant, 2875; and Diesel-engine cooling, 10,585 kw.-hr. This totals 1,095,275 kw.-hr., showing a line loss and minor variations unaccounted for of 251,890 kw.-hr., or 18.7 per cent. of the total generation.

It is interesting to note the aggregate productions of the plant, year by year, from its date of inception in 1908 to the present time, as well as the substantial extention in the earnings since 1911, showing a total net profit for the past five years of $44,450.69. The increase in the output of the station from year to year indicates a constant and encouraging growth in the municipal service both for light and power work, with marked expansion during the past twelve months with the operation of the Diesel unit, as will be noted in the table of total and net earnings.

With a present lighting rate of 7½c. per kilowatt-hour, graded down to 4c. for larger consumption, and with a minimum monthly charge of one dollar, the city is planning to reduce the rate to 4½c., with proportionate decrease for greater quantities used, and a monthly service charge of 50c. The existing charge for heating and cooking is 2c. per kw.-hr., and for power service varying in accordance with consumption as follows: 3c. per kw.-hr. for the first 500 kw.-hr.; 2½c. for the next 500; and 2c. for all over 1000 kw.-hr. used in a month. At the current rate of increase in business for the municipal plant, it is estimated that it will be necessary to install additional generating equipment within the next 24 months, and with further reductions in lighting and power rates at that time, if deemed possible.

Year	Total Earnings	Net Earnings	Output, Kw.-Hr.	Per Cent. Increase
1908–09	.....	.....	720,000	.....
1909–10	.....	.....	740,341	2.8
1910–11	.....	.....	767,511	3.7
1911–12	$42,526.00	$4,505.61	835,639	8.9
1912–13	47,214.29	6,641.00	975,995	16.8
1913–14	51,434.14	6,972.65	1,118,360	14.6
1914–15	51,740.84	11,519.16	1,137,837	1.7
1915–16	54,561.17	14,812.27	1,347,165	18.7

Insulation of Boiler Settings

By Joseph Harrington*

SYNOPSIS—Radiation and air infiltration. A discussion of different types of construction employed in boiler settings, with results from tests showing the losses in each case.

Since a great majority of modern steam boilers are set in brickwork, the construction of the walls may be considered of practically universal interest. In many respects brick forms an unsatisfactory material for this purpose. It is a rigid substance, not yielding to stresses that in a more elastic medium would temporarily distort the shape of the body, but rather develops permanent cracks or fractures under such conditions. These cracks remaining in the setting, grow worse by repeated opening and closing until not only the porosity of the wall as a whole is greatly affected, but the stability of the structure may actually be endangered. I do not know of any practical way in which the physical characteristics of a brick wall can be modified, so that any treatment of this problem must involve a consideration of means to offset the inherent tendency of brickwork to crack under the varying influence of furnace temperatures.

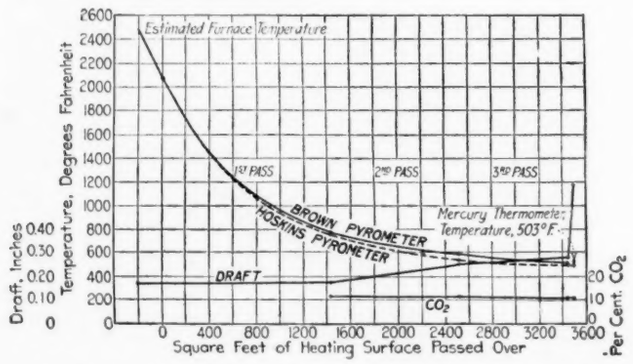


FIG. 1. RESULTS FROM STEEL-INCASED BOILER OPERATING AT 113 PER CENT. OF RATING

Our accepted code for the testing of steam boilers takes notice of the infiltration loss and charges the boiler with this. In the case of the radiated heat from the setting, however, the problem is more difficult to determine, and it has proved impractical to isolate it. The result is, therefore, that it is thrown into the unaccounted-for losses, which are determined by difference. Into this indeterminate residuum are also thrown the losses due to the unconsumed combustible, which ordinarily are not determined.

It is perhaps fortunate in some respects that radiation cannot be entirely controlled. Modern furnace temperatures are such that it is not at present possible to construct refractory material of sufficient heat-resisting power to withstand indefinitely the influence of the furnace.

The temperature of the furnace lining is moderated by the radiation from the exterior surface of the wall. In certain forms of metallurgical furnaces this very influence is depended upon to maintain the refractory material, and it is encouraged by constructing the wall or roof in such a manner as to increase the radiating surface. It is obvious that if all radiation were prevented, the entire wall would eventually reach the temperature of the furnace itself and deterioration would proceed rapidly. Due consideration, therefore, must be given to this matter, and judgment used in designing the furnace wall, with full consideration of the relative magnitude of the losses. In the boiler practice, however, it is more often the case than otherwise, that the temperature of the furnace is within the limit of firebrick endurance, especially if the brick itself is not called upon to carry a heavy burden in addition to resisting the melting or softening influence of the furnace temperatures.

While it is difficult in the analysis of boiler losses to isolate and measure the two losses of infiltration and radiation, attempts have been made to treat them separately in furnace-wall construction. As an offset to the radiation loss alone, layers of insulating brick are being advocated. This brick is nothing more than a substance that has a very low heat conductivity, being generally based upon a siliceous rock containing a high percentage of air space. A form known as "silocel" was used in the instance described later. If one end of such a brick is heated to incandescence, the other end will remain comparatively cool, demonstrating in a striking way its nonconductry qualities.

In building a brick wall of this nature, these insulating brick, which are cut to standard brick size, are built into the wall back of the furnace lining and inside of the exterior course. Since they are able to carry their share of the burden, they are treated just about like any other brick and bonded to the setting as usual. Not less than 4½ in. is recommended in such a construction, and

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a 9-in. course thus placed works wonders with the amount of heat passing through the wall. These brick are laid with mortar made up of the same material, which is finely pulverized and mixed with water. This construction does have the effect of greatly reducing the amount of heat that is radiated from the wall, but owing to the fact of the numerous joints in such construction and the porosity of the brick itself, practically no benefit is derived as regards the prevention of infiltration. When the interior lining expands, these brick are lifted and the joints loosened, so that in the course of time this wall will be just about as leaky as if it were built in the usual manner.

Regarding attempts to offset the infiltration without consideration of the radiation losses, two general methods have been pursued. In the first one a glazed or vitrified brick has been used for the outside course. When this brick is laid up in cement mortar, it makes a construction almost as hard and durable as concrete, has the advantage of being sightly and lends itself to little touches of artistic quality in the appearance of the setting. However, unless this construction is protected in some way, the radiation is inclined to be heavy. The structure of this brick is dense, and the heat transmission is therefore rapid.

Sheet-Steel Boiler Coverings

As an alternate proposition for the prevention of infiltration alone, boiler settings have been covered with sheet steel. If steel alone is used, practical air-tightness may be obtained, but on account of the high heat conductivity of this metal, little or no benefit is derived as regards insulation. I do not know of any practical case, however, where steel alone has been used for this purpose. Whenever a boiler is steel-incased, it is also covered with some form of insulating material. Usually this takes the form of asbestos or magnesia block fastened to the outside of the brickwork. Without any doubt this construction is very successful in the prevention of both losses, but its cost is high, and it is not always possible to convince the purchaser that he should go to the expense of such construction.

It is interesting in the consideration of this thought to note the effect on the results. A 351-hp. Oil City boiler equipped with an Illinois chain grate was thus constructed and subjected to test. The insulation was 2-in. magnesia block and ¼-in. sheet steel plate, riveted together with buck straps and angles, so as to make a thoroughly air-tight joint. Particular attention was given to the gas analysis and temperatures throughout the setting. Figs. 1 and 2 indicate the preceding more clearly than possible by words. A total decrease in the percentage of CO_2 of only 0.85 per cent. is shown in either figure. In the former the boiler was operating at 113 per cent. of rating and in the second test at 157 per cent. of rating, the draft increasing in proportion. These were 24-hour tests, with simultaneous gas analysis taken every 15 minutes, with care as to the location of the sampling pipe and the method of analysis. The loss due to infiltration was about 0.75 per cent. The radiation from this setting was more than it should have been, the steel casing being quite hot, and around the furnace it was impossible to put the hand on the metal. The top, as well as the sides of this boiler, was insulated and covered, and it made a substantial and economical installation.

Another form of combination construction is the application of asbestos cement to the outside of the setting. This construction, which I have employed in several cases, has the merit of being relatively inexpensive and of reducing both losses. Nails or metal strips are driven into the joints of the brickwork, and light galvanized iron wire is fastened thereto over the entire setting. The wire is so arranged that it stands out from

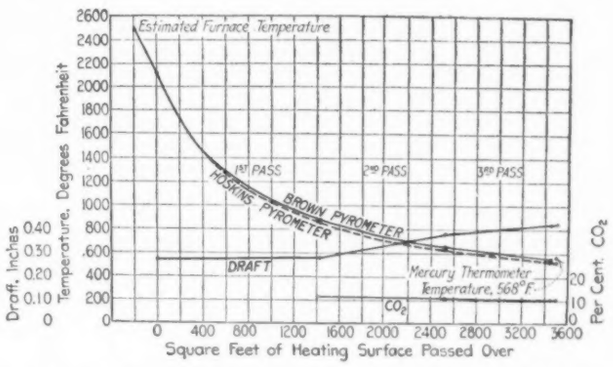


FIG. 2. SAME WATER-TUBE BOILER OPERATING AT 157 PER CENT. OF RATING

the brickwork about ½ in. After this is fairly secured, asbestos cement is mixed to a consistency such that it can be readily applied with a mason's trowel. The outside of this first course in the region of the furnace is scratched before hardening, and later on another ½-in. coating is applied. As the cement shrinks, cracks will develop, but these are brushed full of a thin mixture of the cement until no more appear. Passing over the surface with a wet brush and a final application of the trowel will leave the surface of the cement smooth, upon which cotton cloth, which has been previously shrunk, is applied with glue. It is possible to make a neat covering in this manner, and if sheet metal protection is supplied around all doors, it will last indefinitely. Two coats of lead paint of any suitable color are applied to the cloth. This makes a practically air-tight setting, and it is entirely cold to the touch, except directly around the furnace doors, where it naturally warms up a little. The thickness of this coating should be from 1 to 2½ in.

The application of such a construction to a 500-hp. Stirling boiler will not cost over $300 or $400 and can be applied to old settings without special difficulty. In such an instance where recording instruments were in service, I have noticed a decided rise in both the flue temperature and the CO_2 at the damper. The settings were not in serious condition, and it did not seem possible that the infiltration through the brickwork could have been sufficient to actually affect the flue temperature, but the rise was noticed nevertheless, and all other conditions being the same, the insulation was credited with the result. The CO_2 rose from an average of 9 per cent. to 12 per cent., a saving of approximately 5 per cent. This would have paid for the covering in about six months.

Another instance, which is quite interesting, was the case of a similar boiler that was about eight years old. The brickwork was in a condition that would have been considered good, there being no cracks of great size and the ordinary pointing up of the joints having been attended to. Operating under normal conditions of a lit-

tle overrating, the CO_2 at the damper persisted in remaining at about 6 per cent., whereas at the end of the flame, in this case just above the end of the Stirling arch, the gas analysis was easily maintained at 12 per cent. On the face of this evidence it would seem that as much air was leaking through the setting between the end of the flame and the damper as went into the furnace through the fuel bed—a conclusion that would seem to be almost incredible.

After operating the boiler in this condition for over a month and continuing to get similar data, the setting was covered with the asbestos-canvas covering, as described. Under these conditions another month's operation showed that the normal drop in CO_2 was 2 per cent. instead of 6 per cent. This would indicate a net saving of 12 per cent., which would probably have paid for the cost of the insulation inside of three months. These records were taken with two recording gas-analysis instruments, which were carefully checked with each other and with the orsat. There is no reason to doubt the general accuracy of the results.

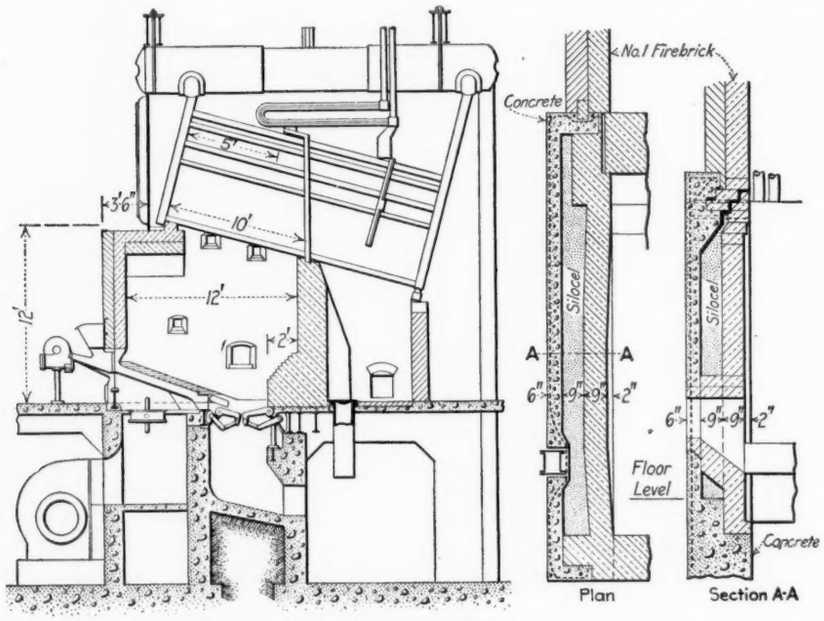


FIG. 3. SETTING OF 500-HP. BOILER AND DETAILS OF WALL CONSTRUCTION

Another interesting instance of complete insulation and radiation protection is encountered in one of the Chicago pumping stations, where a 500-hp. Edge Moor boiler and Taylor stoker were tested. This was a completely steel-incased and magnesia-block insulated setting 2 in. thick. In this instance the entire heat balance is given in the accompanying table. The test was carefully made and in the usual manner. It is also interesting to note that in this case the stack was smokeless. It is my belief, therefore, from the evidence at hand, that complete protection should be provided. It is not proposed or intended to select any one method as the best, but I do not hesitate to advocate the application of this principle.

Some economy can perhaps be derived from a consideration of the various necessities and a reduction of the expense where it is not needed. The radiation loss is obviously greatest where the internal temperature is highest. This applies then particularly to the region of the furnace, and the thickness of the insulating material can properly be reduced as the back of the boiler is approached. In the case of the anti-infiltration element, the reverse is perhaps the case. The draft being the highest near the damper, the tendency to draw air in is decreased as the furnace is approached, and in the case of forced blast equipment, where practically neutral furnace conditions obtain, the probability of heavy infiltration at the furnace is reduced to a minimum. Theoretically, therefore, the necessity for such protection is greater at the rear of the boiler than at the furnace, but practically this consideration disappears when it is remembered that air-tightness in this case is not a variable quality, the paint-covered canvas or the steel covering being just as impervious in one place as in another. However, greater attention should be given to the joints near the rear of the boiler, and especially where the breeching connection attaches to the setting. A little opening at this point would result in a heavy infiltration. A very different treatment of this problem is found in the following design, which I have successfully installed the past season. It not being desired to go to the expense of a complete steel casing, and asbestos covering not being wanted on account of the objection to its possible destruction and ultimate ragged appearance, a compromise was effected whereby the insulation was applied only to the high-temperature zone surrounding the furnace. A special design of interior wall construction was combined with this insulation for the purpose of relieving the expansion strains of the brickwork and preventing the cracks which would ultimately permit of infiltration loss. The construction of this wall is shown in Fig. 3. The outside is a 5-in. concrete wall built with reinforcing bars, placed in proper position to anchor it securely to the foundations and to permit it to carry the load of the upper half of the setting. At the top a concrete shelf is projected inward sufficiently to permit of both the firebrick and red-brick portions of the upper wall being carried thereon. This means that the weight of the brickwork above the tube line is carried on this concrete wall and in no way throws any load on the furnace lining.

To protect the concrete wall and to reduce the loss by radiation, there is a 9-in. course of insulating brick built integral with the 9-in. firebrick lining. This 18-in. thick construction extends from the grate level to the tube line, for the entire depth of the furnace. To protect it against any tendency to fall inward, a 2-in. curvature is provided, which presents a concave surface to the fire. Above the lining there is a ½-in. expansion space. This wall stands by itself, without any load on it whatsoever other than its own weight, and is free to expand. The insulating backing performs two functions: First, the prevention of heat transfer to the concrete wall, and ultimately to the exterior air; and second, by preventing this radiation causes the temperature of the lining to be substantially uniform throughout.

In the consideration of this matter I felt that part of the failures of furnace walls were due to these two causes, and if the brickwork could be relieved of the burden of the load and unequal expansion, a long life would be more likely to result.

The first setting of this type was made with only 4½ in. of insulation, although the later ones were built as already described. In the first setting the temperature readings were taken by drilling holes to the various points and inserting therein thermo-electric couples. Temperature readings were taken at frequent intervals for several hours, while the furnace was operated at constant rating. Steady temperature conditions were obtained, and recorded. These are shown on the accompanying diagram, Fig. 4, as well as those taken simultaneously in a similar manner at similar points inside of a much thicker solid firebrick wall. The latter is the wall at present on the opposite side of this furnace, and is the center wall of the future battery. Wooden blocks wedged into recesses in the outside face of the brick wall completely burned out by a slow charring process in a few days, showing that the external surface of this wall reached a considerable temperature at some time or other.

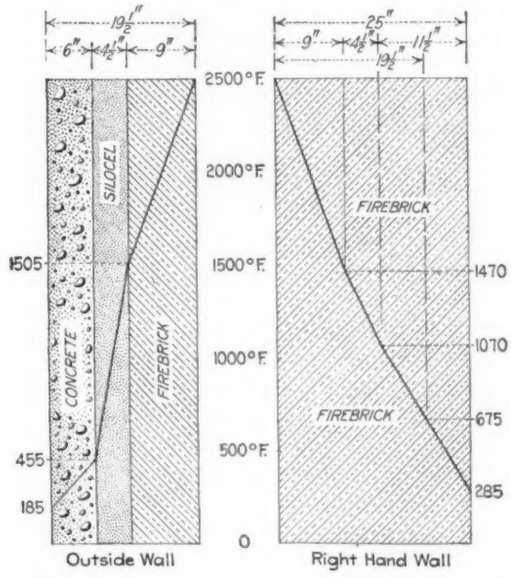


FIG. 4. COMPARATIVE TEMPERATURE DROPS THROUGH INSULATED AND SOLID FIREBRICK WALLS

In the case of the new settings with the 9-in. brick insulation, the surface of the concrete wall is only warm to the touch.

This particular installation also gives interesting evidence regarding the effect of this construction on the remainder of the brickwork. In the case of the center wall on the right-hand side of this furnace, a heavy crack developed within the first three days of operation. This crack was vertical and just back of the buck stay, which is opposite to the first flame plate and bridge-wall. It marks the line dividing the high-temperature zone from the cooler zone of the second pass. The cause of this fracture was the expansion of the furnace lining, which in this particular case carried the entire wall. It heaved up more than did the wall back of the bridge-wall, and the brick setting was not sufficiently elastic to permit of this unequal expansion. A stress developed which ruptured the brickwork from top to bottom. On the other hand, the left side of this setting has never developed any cracks and for a brick setting is as tight as it is possible to make it. Photographs of the interior of this furnace after six months' continuous operation, at high ratings, show the walls to be in perfect condition.

HEAT BALANCE PER POUND OF COAL AS FIRED

	B.t.u.	Per Cent.
Heat per pound coal as fired	10,834	100.00
Heat absorbed by water in boiler	7,700	71.10
Heat absorbed by steam in superheater	457	4.19
Necessary Losses		
Heat absorbed by moisture and H_2O from burned H up to temperature steam	564	5.21
Heat absorbed by theoretical amount dry gases up to ** temperature steam	596	5.50
Heat available for unit	9,674	
Highest theoretical efficiency		89.29
Furnace and Grate Losses		
Heat loss due to combustible in ash	368	3.39
Heat absorbed by excess air up to temp. steam	99	0.91
Heat loss due to production of CO	0	0.00
Heat available for boiler	9,207	
Furnace and grate efficiency		95.17
Boiler Losses		
Heat loss due to theoretical gas, moisture and H above temperature steam	278	2.57
Heat loss due to air leakage through setting	120	1.11
Heat loss due to radiation and unaccounted for	652	6.02
Boiler efficiency		88.60
Combined efficiency		75.29
Ratio: Combined efficiency to highest theoretical efficiency		84.32
Corrections		
Per cent. of boiler output used by fan engine		2.34
Deduction from combined efficiency due to fan engine		1.76
Heat equivalent of waterback cooling water, per cent. of output		0.42
Accretion to combined efficiency account of waterback		0.32
Net combined efficiency		73.85

It is therefore felt that this construction is going to work out satisfactorily and do away with many of the expansion troubles of the brick boiler setting.

Electric Motor Drive in Sugar Cane Mills constitutes one of the most important developments in that industry in recent times, and the advantages besides the economy in fuel are greater ease of installation and lower first cost. In operation it is possible to vary the speed of the rolls, relative to the others and independently of them, in accordance with the percentage of fiber in the cane and the quantity of maceration water; it is also possible to stop, start or handle in any desired way any one of the various mills without affecting the operation of the others; and should one mill become disabled, it does not affect the remainder of the plant. There is less danger of breakage, as neither the inertia of the moving parts nor the power of the motor (only of sufficient size for one mill) will be enough to cause breakage should a sudden resistance, such as a piece of scrap or railroad iron, be accidentally encountered in the roll, as each motor is protected by overload cutouts. If the controlling apparatus is installed on a convenient platform, according to the modern idea of centralized control, but one man is needed for the complete control of all the grinding mills. One motor carried as a spare may in case of accident be quickly placed in position in any part of the mill and operations resumed. The electric drive makes a neater plant, requires considerably less space, and there is complete freedom from large engines and their piping.

Soldering Iron to Iron—To solder two pieces of iron together, brush both with a stiff wire brush to remove all grease, scale or rust, then apply a solution of sal ammoniac and water (half and half) and let it stand for a minute or two. Apply cut acid to one of the pieces and rub with a hot soldering iron until the acid and sal ammoniac have dried, then treat the other piece in the same manner. Next, apply the cut acid and a little solder to each piece and rub with the hot iron until well "tinned." If the solder does not stick well, put on a little more acid. Sometimes if the solder is rubbed with a piece of cloth or waste while hot it will be spread more evenly and stick better. Finally apply solder and heat both pieces, when in their correct position, with the soldering iron or a blow torch until the solder melts and joins the pieces. To solder tin, use cut acid or rosin as a flux and proceed as stated.

Jacketed-Tank Type of Self-Cooling Transformer

SYNOPSIS—A description is given of a self-cooling transformer, employing a jacketed tank to provide a large cooling surface.

The transformer has been called the simplest of electrical devices, and probably in some respects this is true, especially from an operating standpoint, but as the modern transformer is constructed its design is far from a simple problem. The large transformer is a very efficient piece of apparatus, the total losses being but a small percentage of the total output. Efficiencies of 98.5 to 99 per cent. have been attained in large apparatus of this type. However, the exposed surface is comparatively small, and as there are no moving parts to induce ventilation, as in generators and motors, some means must be provided for carrying off the heat. It is in this respect that the greatest apparent change has been made in the design.

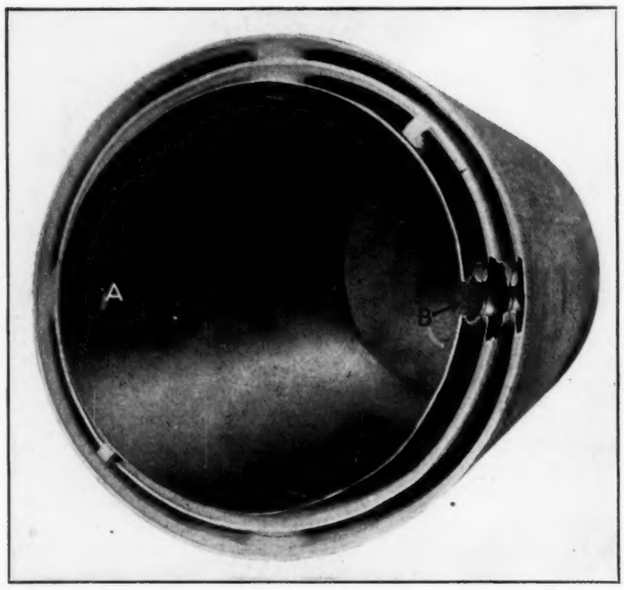


FIG. 1. JACKETED TANK FOR 2000-KV.-A. TRANSFORMER

As first constructed, transformers were provided with no artificial means of cooling, consequently they were limited to very small sizes. The next step was to fill the case with oil, and this proved to be the development that has made possible the modern high-voltage transformer. Air-cooled transformers have been used to some extent in substations where an attendant is always at hand to see that the supply of cooling air does not fail. This type of equipment is limited to about 33,000 volts on account of the insulation, and to capacities of about 1000 kv.-a. Beyond this voltage the windings must be immersed in oil. To assist in getting the heat out of the oil, cooling coils have been introduced, but when these are used, an attendant must always be at hand to see that the cooling water does not fail. Furthermore, they cannot be used in places where there is danger of the circulating water freezing. The self-cooling transformer with a fluted tank is limited to about 500 kv.-a. in capacity, owing to external dimensions.

With the development of the large hydro-electric stations, many of which are far away from industrial centers, a demand was created for large self-cooling power transformers that could be located and operated out-of-doors under all manner of conditions. To meet these requirements the Allis-Chalmers Manufacturing Co., Milwaukee, Wis., has developed its self-cooling type. The distinctive feature of this type is the jacketed tank which provides three or more cooling surfaces for the oil. The tank for a 2000-kv.-a. single-phase transformer is shown in Fig. 1. It is made of heavy boiler plate and is surrounded by one or more jackets connected to it at the top and bottom by tubular openings *A*. A section view at *B* shows the cross-section of jacket and tank and how they are connected into each other.

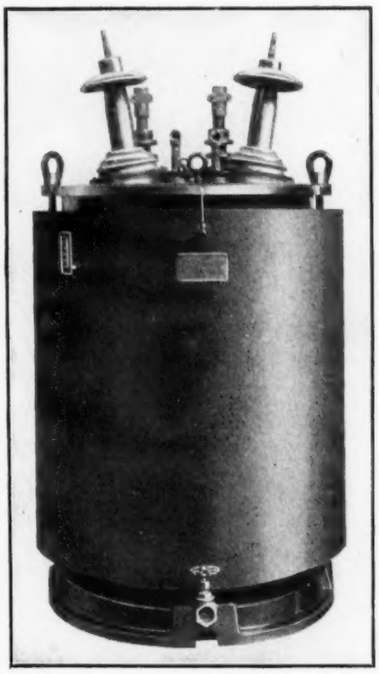


FIG. 2. TRANSFORMER COMPLETE WITH JACKETED TANK

The heated oil rises to the top of the tank, where it passes through the tubular openings to the cooling jackets, while the cool oil flows in at the bottom. The oil cur-

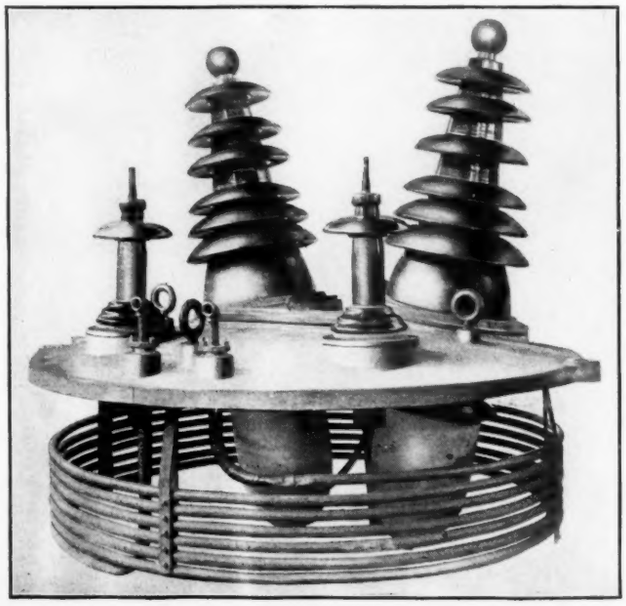


FIG. 3. COOLING COILS AND INSULATORS FOR A 150,000-VOLT TRANSFORMER

rents are thus directed in definite paths, consequently one does not interfere with the other, thus, permitting a constant circulation of the oil. As the oil passes down through the cooling jacket, the heat is liberated to the various surfaces and the annular spaces between the tank and jackets serve as flues and provide a large and rapid circulation of air, which quickly diffuses the heat.

The joints between the tank and jackets are welded, making them absolutely oil-tight and giving a strong mechanical construction. The tank is supported on a cast-iron base and fitted with a cast-iron cover which, in the case of transformers for outdoor installations, is made weatherproof. A complete 200-kv.-a. 33,000- to 2400- and 480-volt single-phase 60-cycle unit is shown in Fig. 2.

For indoor work, and also out-of-doors where conditions will permit, cooling coils may be used. These coils are made of seamless copper tubing and suspended in the upper part of the tank. Fig. 3 shows the cover with high- and low-voltage terminals and auxiliary cooling coils for a 500-kv.-a. 60-cycle single-phase 150,000-volt transformer. Under ordinary conditions this type is operated the same as the self-cooling transformer, the flow of cooling water being cut off from the cooling coil. In case of emergency or at times when the transformer must carry a heavy overload, the water-cooling coils are used and the transformer temperature is thus kept within reasonable limits.

Transformers of this type are economical both in first cost and operation, for installations where water is expensive and where the load conditions are suitable. With water cooling, the transformer load can be considerably increased, but the water need be used only during the period or season of heavy load.

Steam-Engine Troubles—Foundations

By H Hamkens

SYNOPSIS—The weight of the foundation should be four or five times that of the engine; engine weights; allowable weight per square foot; piling. Shallow and deep foundations. Construction and location of the templet. Use of the transit or engineer's level for lining, squaring and locating bolt holes and openings. Concrete mixtures.

After the most advantageous location for the engine, size of engine room, etc., have been determined, the next thing to be considered is the foundation—its depth, size, weight and the material of which it is to be built. The depth depends largely on the ground; on general principles it is better to spread the foundation over a wide surface than to make it narrow and deep; weight and sufficient area for a good hold on the ground are the principal requirements. If bedrock can be reached within a reasonable distance that of course is to be preferred, but in most cases it is more likely that the ground is clay or sand, in which case a subfoundation of concrete 12 to 18 in. thick should be spread over an increased area on which to build the foundation proper. If the ground consists of mud, piles must be driven and covered with a substantial layer of concrete. The piles may be driven about three feet apart to hardpan or bedrock, as shown in Fig. 169, their tops trimmed to an even height and a concrete footing not less than 24 in. thick spread over the surface. The construction can be much strengthened by placing steel rods crosswise in the concrete near the top and bottom. The upper surface must be left rough to make a good bond with the engine foundation. The piles themselves may be made of reinforced concrete if properly designed.

The weights of both engine and foundation must be taken into account in computing the area over which the subfoundation should extend. Average soil will support about three tons per square foot, but to be on the safe side it is best to allow only 2000 lb. The greatest weight of an engine is located at, and supported by, the bearings, where also the greatest vibration takes place and where the main support in the foundation must be given. Vertical Corliss engines, few of which are built now, may be left out of the question, and only the horizontal construction need be considered. The table states the approximate over-all dimensions and weights of

DIMENSIONS AND WEIGHTS OF FOUNDATIONS

Size of Engine, In.	Main Bearing Length Ft. In.	Main Bearing Width Ft. In.	Outer Bearing Length Ft. In.	Outer Bearing Width Ft. In.	Depth Ft. In.	Wt. of Foundation, Lb.	Wt. of Engine and Wheel, Lb.
12x30	18 0	5 0	8 0	4 0	5 0	92,000	24,000
14x30	19 0	6 0	9 0	4 0	5 0	114,000	30,000
16x30	20 0	6 0	9 0	4 0	5 6	128,000	34,000
18x30	20 0	6 6	10 0	5 0	6 0	165,000	38,000
18x36	22 0	6 0	11 0	5 0	6 0	180,000	44,000
20x36	22 0	7 0	12 0	5 0	7 0	194,000	55,000
22x42	24 0	7 0	13 0	5 0	7 6	280,000	70,000
24x42	25 0	7 6	14 0	5 0	8 0	320,000	80,000
26x48	30 0	8 0	15 0	5 0	9 0	426,000	100,000
28x48	31 0	9 0	16 0	5 0	9 0	484,000	115,000
30x48	32 0	9 0	18 0	6 0	10 0	600,000	130,000

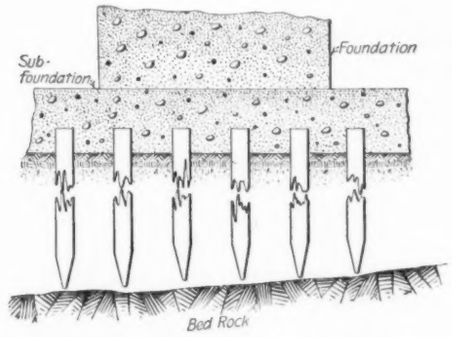


FIG. 169. PILES SUPPORTING FOUNDATION

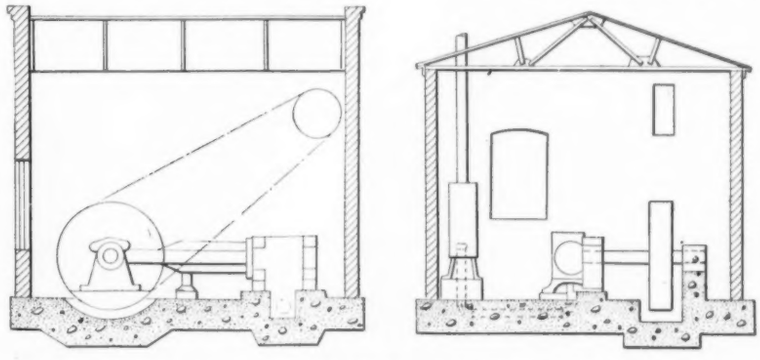


FIG. 170. SHALLOW FOUNDATION SUPPORTING ENGINE AND BUILDING

foundations for simple, heavy-duty, belted engines and also the weights of the engines themselves. From this table it is seen that the weight of a foundation should be four to five times the weight of the engine, which is considered ample to counteract vibration.

On mushy ground special precautions must be taken to counterbalance the inertia of the reciprocating parts, otherwise the rocking motion may be communicated not only to the engine house, but to all the buildings in the neighborhood on the same swampy soil. For direct-connected engines about 33 per cent. should be added to the weights of engines and foundations given in the table, and the piers for the outer bearing and the generator must be connected at the base to the main foundation, giving them a broad bearing on the ground. If the depth of a foundation for a certain size of engine is made less than stated in the table, the length and width must be increased to maintain the weight.

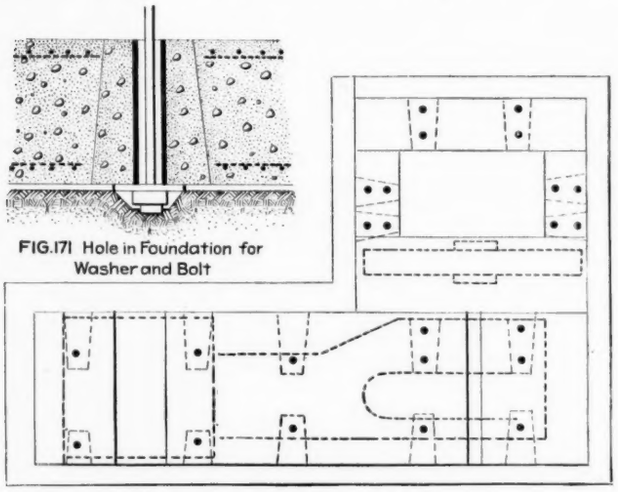


FIG.171 Hole in Foundation for Washer and Bolt

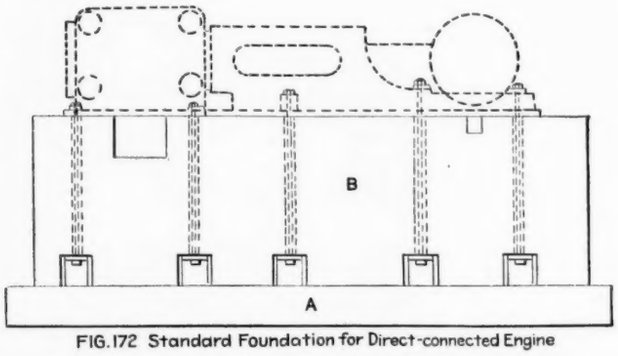


FIG.172 Standard Foundation for Direct-connected Engine

FIGS. 171 AND 172. STANDARD FOUNDATION FOR DIRECT-CONNECTED ENGINE

In rocky ground or in places where water is close to the surface or sewers interfere with the work, it is often cheaper and more convenient to make a foundation shallow and extend it over a wide surface, than to make it deep. To give a shallow foundation sufficient strength it should be reinforced, for which purpose old rails, I-beams, angles or bars may be used to advantage. A little rust on them will do no harm, but they must be free from mud and dirt. The foundation bolts must reach all the way through, with the washer on the under side.

Fig. 170 shows an example of a very shallow foundation which was built for a 12x30-in. belted engine. It was extended under the whole engine room, supporting even the walls of the building. It was made 24 in. deep, of concrete reinforced by two rows each, at the top and bottom, of ½-in. steel rods laid crosswise and spaced 3 in. apart. Depressions of sufficient depth were made to form the flywheel pit and the trench for the exhaust pipe. Large holes were left for the foundation bolts and washers, as shown in Fig. 171, which were set later by means of a templet; the holes, which taper toward the top, were filled with concrete. The top of the foundation was finished smooth and forms the floor of the engine room. The reason for the construction was that a large sewer about four feet below the surface of the engine room could not be removed without considerable expense.

Fig. 172 shows a standard foundation for a direct-connected engine. *A* is a slab of concrete which forms the subfoundation, and *B* represents the foundation proper. Some years ago foundations were given various shapes, which sometimes followed the outline of the engine. A favorite construction was to make the sides battered, but now, when foundations are mostly made of concrete, straight lines are followed in all directions. This is done to simplify the forms that have to be built for the concrete.

Erect the Building First

A mistake is often made in having the engine erected before the building for it is completed. As a rule, time is lost on the building and the aim is to make up for it by hurrying the work about the engine. Although a Corliss engine will stand a good deal of abuse and will sometimes run under very unfavorable conditions, it is a mechanism designed and built with care to do effective service for a number of years. It is therefore not unreasonable to expect that it should be handled with care and not be exposed to dust, dirt and the elements. A sand test is not required, as on a machine gun or cannon, because an engine is not supposed to work under such conditions, but in a nice, clean room, free from dust, rain or sleet. Many an engine is ruined by rough usage at the start.

Assuming, then, that the advice implied in these remarks has been followed and that the walls and roof of the engine room are finished, windows put in, the hole for the foundation dug and the subfoundation constructed, the next thing to do is to locate the center line of the engine, place the targets on the walls or other convenient places and establish a line of strong fishcord from which plumb lines can be dropped to locate the templet, as shown in Fig. 173.

The templet is usually made of 1-in. boards having one long center board (for large engines made of two lengths), with frames for the cylinder and pillow block and cross-pieces for the guide screwed on. The center lines of the engine, cylinder and shaft are marked on the board, blocks of wood are fastened to the frames giving the thickness of the metal at the bolt holes, and the holes for the foundation bolts are drilled through. The under side of the boards constitutes the base of the engine, outer bearing, etc. The templet must be well supported on framework and posts strong enough to carry the heavy bolts and washers. After it is lined up and leveled, the bolts are hung in place with the cast-iron washers at the lower end. The upper ends of the bolts should project about ½ in. above the nuts in order to make sure of having enough thread for full nuts when the engine is put on the foundation. Boxes of ⅝-in. or ¾-in. boards should be built around the bolts with ¾-in. or 1-in. space

on each side, giving them sufficient play to allow for irregularities in the castings. They may be made tapering toward the lower end with the object of removing them after the concrete has set, although there is no objection to letting them remain in the foundation. The templet for the outer bearing and, if the engine is direct-connected, that for the generator are located in a similar way, special care being taken to set them level and square with the main templet.

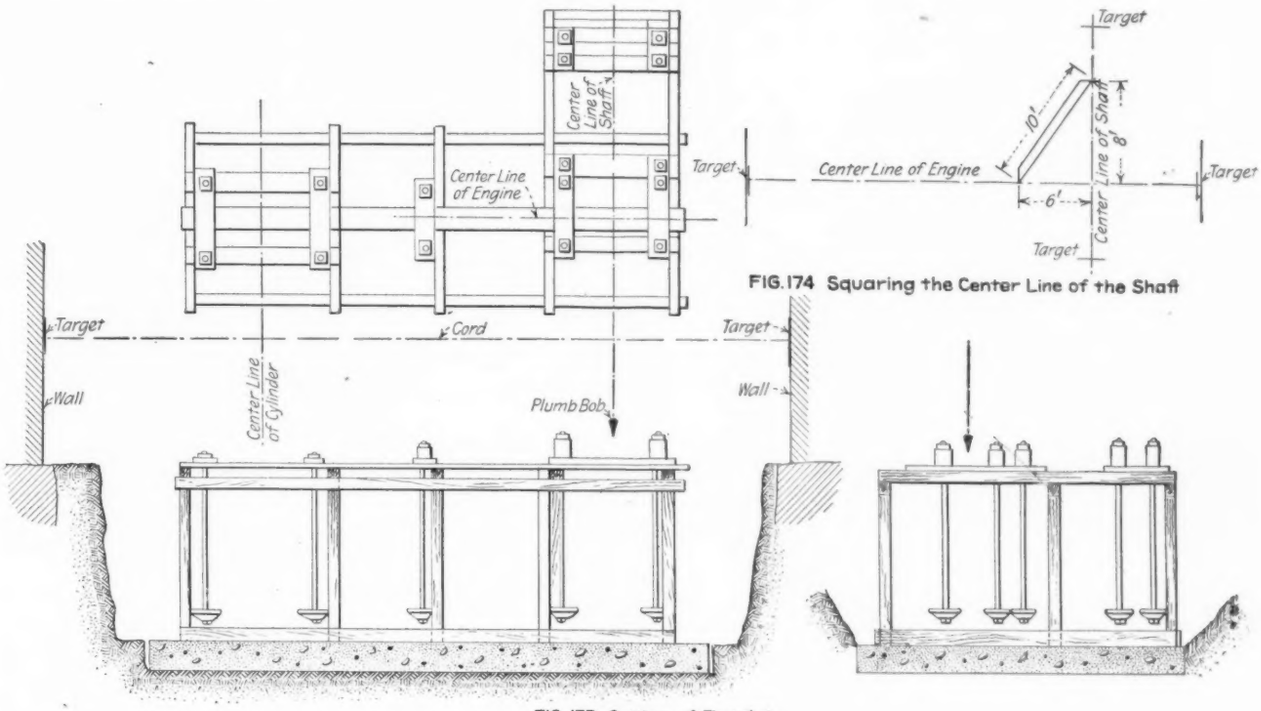


FIG. 173 Setting of Templet

FIG. 174 Squaring the Center Line of the Shaft

FIGS. 173 AND 174. LOCATING THE TEMPLET FOR THE ENGINE FOUNDATION BY TARGETS AND LINES

A simple way to square the center line of the shaft with the center line of the engine is to stretch another line across the main line on the same level and adjust it as shown in Fig. 174. Any multiple of the figures 3, 4 and 5 laid down to any scale will form the two legs and hypotenuse of a right triangle; as a rule 6, 8 and 10 ft. are the accepted standards for lining up an engine; therefore, if two pieces of cord are located 6 and 8 ft. respectively from the intersection of the two lines and the distance between the two fixed points is made 10 ft., the two lines will be square to each other. To prevent any error a plank 4 in. wide and 10 ft. long, pointed at both ends, may be used, with distances of 6 and 8 ft. marked from either end. This is better than a tapeline or rule. The outer bearing and generator templets are then located by plumbing down to the center lines marked on them. Targets should also be established for the center line of the shaft.

Templets for cross-compound engines are lined up the same way. Parallel center lines are stretched, one for each side of the engine, and the center line of the main shaft is located at right angles to both of them in the manner described. For adjusting the two sides to the same level, a long straight-edge or a transit may be used.

Except on smaller-sized engines and where the foundation is crowded against walls or the ground is rocky and hard to excavate, the washers should not be built in the foundation, but located in pockets accessible from the outside. For this purpose boxes, as shown in Fig. 175, will be required; they must be large enough for a person to get into to hold the washers and nuts when the bolts are put in place. The boxes must be secured in position with the holes for the bolts directly under the corresponding holes in the templet. The foundation-bolt boxes are fastened to the templet and lower boxes, the vertical position to be verified by a plumb line.

The boxes for the flywheel, generator and crank-pits should now be put in place and also those for the trenches for the exhaust pipe and the drain pipes. The form for the foundation should be made of 1½-in. or 2-in. boards running horizontally, well-braced on the outside and, if necessary, held together by means of bolts or wire to withstand the pressure of the concrete and of the tamping, as shown in Fig. 176.

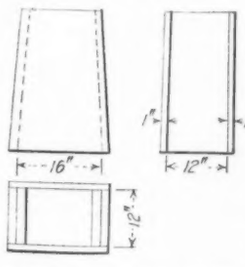


FIG. 175. FOUNDATION-BOLT BOXES

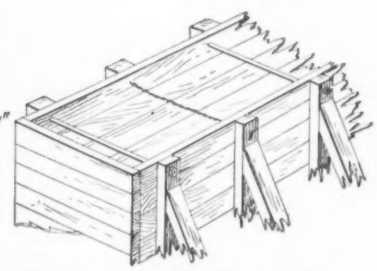
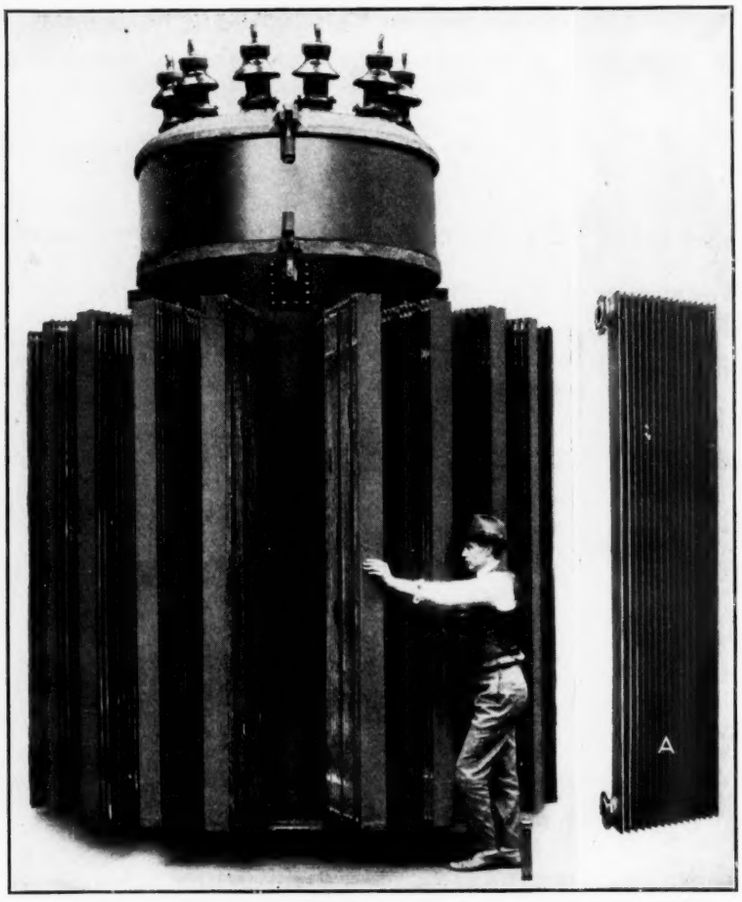


FIG. 176. SHOWING BRACING FOR FORMS

A good mixture of concrete for engine foundations may be made of 1 part of portland cement, 2 parts of sharp sand and 4 parts of gravel or broken stone. The work of mixing the concrete and filling it into the form should be done under the supervision of an experienced mason. Even if the work is rough, it will lead to trouble if only inexperienced help is employed. To prevent sticking,

the boards should be made wet before putting in the concrete if the foundation is to be plastered; otherwise grease or soap may be used. Concrete is placed in the form in layers 6 to 8 in. thick and tamped down with a light rammer. If the foundation is not finished in one day, the top layer must be kept wet overnight by covering it with wet rags. The next day the surface must be roughened and a strong mixture of cement and sand used to make a good bond with the next layer. The forms must stay around the foundation for two or three days and on large foundations about a week before they are removed.



THREE-PHASE, 600-KV.-A. INDUCTION VOLTAGE REGULATOR

On large installations for rolling mills or central power plants the engine foundations are built before the walls of the buildings are constructed, and the center lines and levels are located and the templets set with a transit. In order to avoid carrying the vibrations from the engines into the walls, care must be taken not to connect the foundations of engines and buildings; sand cushions must be provided if they approach one another closely.

The top of the concrete should stop about two inches below the floorline, which includes 1-in. space for grouting. This will locate the base of the engine bed and soleplates 1 in. below the floor line without any unsightly projections and offsets. The templet can be removed as soon as the foundation is completed, but all the boxes must stay in place until the concrete has set. The foundation-bolt holes must be protected from cement or dirt dropping into them. Pieces of wood can be nailed over the top, or waste, burlap and similar material may be used to close the holes temporarily.

[*The next article deals with erecting the engine.*]

A Giant Voltage Regulator

We are all familiar with the mechanical and electrical giants in the form of boilers, engines, generators, motors and transformers. However, there has recently come into existence another electrical monster in the form of a self-controlled induction feeder-voltage regulator built by the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Penn. The figure shows the largest piece of equipment of this type ever constructed. The regulator is of the oil-insulated, self-cooled type and is designed to operate outdoors with full automatic control and is rated at 600 kv.-a. three-phase, 60 cycles, 13,200 volts, with 10 and 20 per cent. regulation at 262 and 131 amperes. Instead of the fluted containing tank generally used for this type of equipment, the tank for this giant is built of boiler iron and equipped with detachable external radiators. This construction provides numerous vertical circuits in multiple, which conform to the natural circulation of the cooling air and oil and give a large radiating surface. The radiators, one of which is shown at *A*, are constructed of ingot iron bent into corrugations, with all the seams welded. Cast-steel flanges are welded to the radiators and the tank; these flanges are machined perfectly true and the radiators bolted to the tank with a special gasket between the machined surfaces, which makes a permanent oil-tight joint. This device was built for the Southern Power Co., and is to be connected to the low-voltage side of a 6000-kv.-a. bank of 44,000- to 13,200-volt transformers on the power company's line at Spray, N. C. By the use of this regulator the power from the line will be delivered to the Thread Mill Co. mills, with the voltage maintained continuously at normal value.

In Figuring the Size of Wire required for a given circuit, the size obtained from the well-known formula, $\text{cir.mil} = \frac{1 \times D \times 21.6}{D}$, gives the size in circular mils, whereas the sizes of wire except those above 4-0 is given by numbers, and it is necessary to have a wiring table to determine the commercial size. The size of wire in circular mils doubles (approximately) every third number above No. 10, which has an area of 10,380 cir.mils for example.

	The Exact Size Is
No. 10 wire is 10,380 cir. mils	10,380
No. 13 wire is 5,290 cir. mils	5,178
No. 16 wire is 2,645 cir. mils	2,583
No. 19 wire is 1,327 cir. mils	1,288
No. 10 wire is 10,380 cir. mils	10,380
No. 7 wire is 20,760 cir. mils	20,816
No. 4 wire is 41,520 cir. mils	41,740
No. 1 wire is 83,040 cir. mils	83,690
No. 3-0 wire is 166,080 cir. mils	167,800

Any intermediate size is approximately a proportional amount of the next larger size. This table is not exactly correct, but is fairly approximate, and when the size is figured in circular mils and the next larger size taken, as is usually the rule, the sizes obtained in this manner will be found correct.

The Water, Light and Power Industry of the State of New York had 7 per cent. fewer employees and paid out 4 per cent. less wages in the month of January, 1917, than in the previous month; but compared with one year ago, there were 4 per cent. more employees and 12 per cent. more wages paid.—New York State Industrial Commission.

The Electrical Study Course—Elements of Electricity—III

SYNOPSIS—The previous lesson compared the flow of an electric current from a voltaic cell with the flow of water from a centrifugal pump and showed how voltaic cells or centrifugal pumps could be combined to increase the pressure. In this lesson it is shown how to group voltaic cells so that the pressure will remain the same as that of one cell, but the current may be increased; also how to group the cells for increased pressure and current.

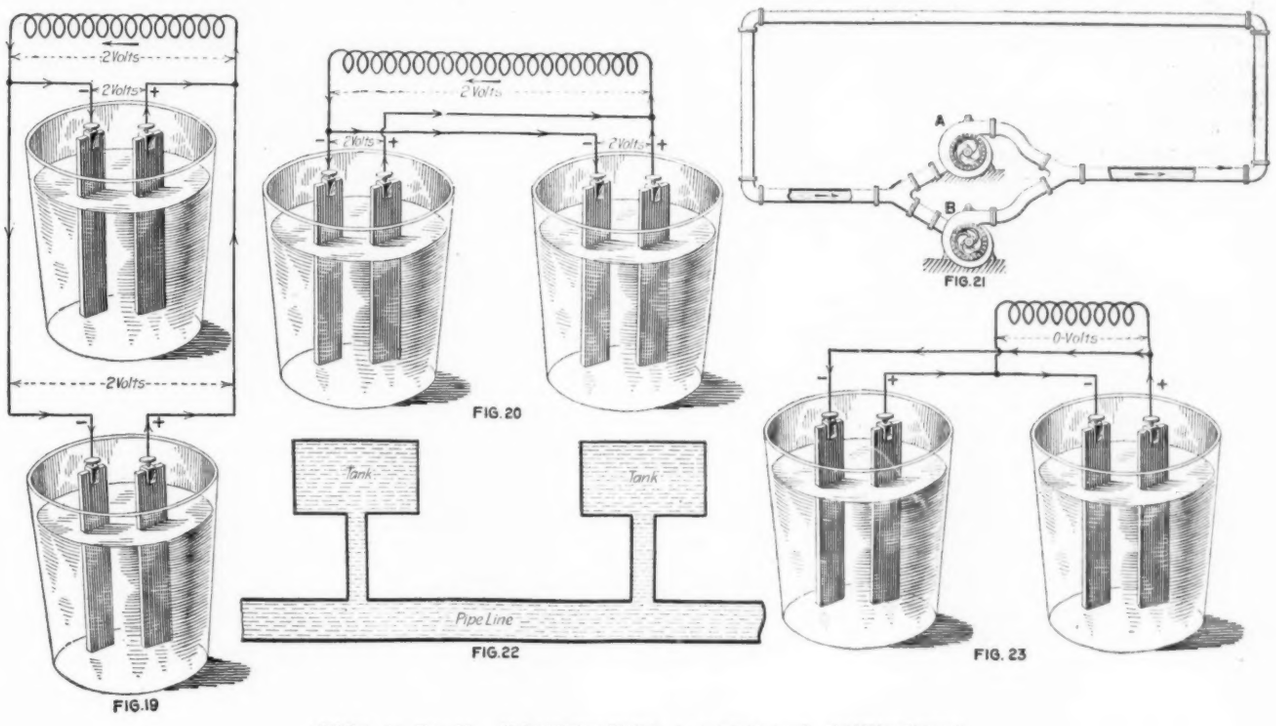
Although the pressure of a voltaic cell is not affected by its dimensions, nevertheless the dimensions are an important factor when the amount of current that can be taken from it is considered. The number of amperes that can be taken from a voltaic cell is almost in direct proportion to its cubic contents; that is, a cell of 10 cu.in. volume will have about twice the ampere capacity as one of 5 cu.in. volume, with the elements properly proportioned. It is not general practice to make voltaic cells very large in volume, therefore more than one cell must be used. To increase the current capacity and have the voltage remain the same, the cells are connected in parallel or multiple. Note that a parallel and a multiple connection are one and the same thing.

Two voltaic cells are shown connected in parallel, or multiple, in Fig. 19. It will be seen that the positive terminal of one cell has been connected to the positive of the other, likewise for the negative terminals. This is a very simple connection and easy to remember, and the rule for it may be written: Connect like poles to like poles and bring out a positive and negative lead from the group.

A more common arrangement of a parallel connection is shown in Fig. 20. This is the same as in Fig. 19; that is, the positive terminals are connected together, also the negative terminals, with a positive and negative lead brought out.

Connecting two voltaic cells in parallel is similar to connecting two pumps so that they both discharge into the same system, as in Fig. 21. The pumps are so connected that one may be shut down and only one operated. If the two are running, the pressure would not be any greater than when one is running, but it would be expected that two similar pumps of the same size would deliver twice as much water at the same pressure as one. The parallel connection is also similar to a pipe line that is being supplied from a storage tank. If one tank is used, a certain amount of water at a given pressure may be drawn off before the tank will have to be filled again. On the other hand, if two tanks are used, the same size, and connected into the pipe line, as in Fig. 22, twice as much water will be supplied to the pipe line, but the pressure will be the same as for one tank.

In connecting battery cells or electric generators in parallel it is essential that like terminals be connected together. If unlike terminals are connected, as in Fig. 23, it will cause a closed circuit between the cells and no current will flow through the external circuit. A connection like this would quickly destroy the cells on account of the heavy current that would circulate between them. This connection is similar to connecting two pumps, as in Fig. 24. In this case pump *A* will tend to cause the water to circulate around through the system in the direction of the arrow *a*, and pump *B* in the direction of arrow *b*. It is self-evident that opposite currents cannot



FIGS. 19 TO 23. ILLUSTRATING A PARALLEL CONNECTION

flow around through the system. However, the water from *A* can discharge into *B*, and pump *B* into *A*, causing a circuit through the pumps, as indicated by the arrows *c*, similar to the electric circuit in Fig. 23.

If it is desired to connect more than two cells in parallel, the same general rule is followed as in Figs. 19 and 20; namely, connect like poles to like poles and bring out two leads of opposite polarity. Fig. 25 shows four cells connected in parallel. Here the four positive terminals are connected together, also the four negative terminals, with a lead coming from the positive and another from the negative to the external circuit *L*. The

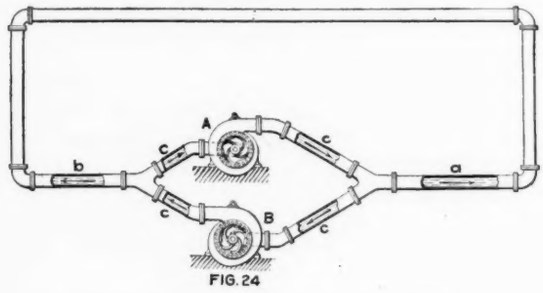


FIG. 24. PUMP ANALOGY OF FIG. 23

arrowheads indicate the direction of the current which flows from the positive of each cell through the external circuit and back to the negative of each element, and if all cells are alike they would each deliver an equal amount of current to the external circuit.

There are conditions that require not only a greater electric pressure than can be supplied by one cell, but also a greater current. We have already found out that connecting cells in series increases the voltage by the number connected. Also by grouping cells in parallel, the current may be increased according to the number of cells so grouped. To increase the voltage of the group and at the same time make it possible to increase the current, a number of cells can be connected in a combination of a series and a parallel grouping. There are two ways of doing this, first, series parallel, and second, parallel series. However, either connection produces the same result. In Fig. 26 are shown four cells connected in series parallel. Cells *A* and *B* are connected in series, also *C* and *D*. Then the positive and negative terminals of group *CD* are connected to the positive and negative terminals of group *AB* respectively. By comparing Fig. 26 with Fig. 19 it will be seen that the two groups in Fig 26 are connected the same as the individual cells are in Fig. 19. In this way cells can be grouped to obtain any voltage or current capacity desired, depending upon the number of cells so grouped.

The second method is to group the cells in parallel and then connect the groups in series, as in Fig. 27, which shows four cells connected in parallel series. Cells *A* and *B* are connected in parallel, also cells *C* and *D*. Then the two groups are connected in series. It will be seen that if the connection *XY* is removed, the grouping of *A* and *B*, and *C* and *D*, will be the same as that in Fig. 19. The voltage between the outside leads in Figs. 26 and 27 is the same, but across the group it is different. In Fig. 26 two cells are connected in series in each group, which gives four volts across their terminals, the sum of the volts of each two cells connected in series. In Fig. 27 the two cells in each group are connected in parallel; consequently the volts across the group is that of one cell, or in this case two volts. The flow of the current is indicated by the arrowheads. Starting from the terminal *E*, the circuit is through the load *L*, to terminal *F*, where the current divides, part of it flowing through cell *A* and part through cell *B* to point *X*, where the current combines again and flows to *Y*, where it again divides, part going through *C* and part through *D*, after which it combines at *E*, thus completing the circuit. Fig. 28 shows the same connection as in Fig. 27, with a somewhat different arrangement of cells. It will be seen that cells *A* and *B*, also *C* and *D*, are grouped as in Fig. 20, and then the two groups are connected in series at *X* and *Y*. By tracing out the circuits as indicated by the arrowheads, they will be found to be identical to those in Fig. 27.

As for the results obtained from grouping cells, there is very little preference between the series-parallel and the parallel-series connection. However, in grouping lamps or other devices on a circuit, the series-parallel connection is given the preference and has distinctive advantages, which will be pointed out in a later lesson. The different combinations in which elements can be grouped on an electric circuit are almost innumerable, but all the various groupings are only a modification of series and parallel connections; consequently, by getting the idea of these two connections firmly fixed in the mind, it will greatly assist in an understanding of all other combinations.

In the statement, "The ohm is the equivalent of the resistance offered to the flow of an electric current by a column of mercury 106.3 c. (27 in.) long by 1 sq.mm. (0.00155 sq.in.) in cross-section at 32 deg. F.," in the lesson published in the Feb. 27, 1917, issue, page 290, second column, third paragraph, (27 in.) should be changed to (41.85 in.).

Need of Uniform Boiler Laws

The following excerpt presents a concrete instance of the confusion and inefficiency arising from a multiplicity of boiler laws and is a powerful argument for uniformity.

The Hon. Samuel McCall, Governor,
Commonwealth of Massachusetts,
Boston, Mass.

Dear Sir—We are encountering a great deal of trouble in the effort to have vertical tubular boilers, which are used to operate hoisting engines on our pile drivers, so constructed that they will be admitted into every state in the Union.

We have over forty outfits working on concrete-pile foundations, operating in practically every state from Massachusetts to Colorado. The nature of our work necessitates shipping the machines from state to state, it being almost impossible to keep certain boilers in one location. Of course this can be done, but it is an expensive and inefficient proposition.

Shortly after the Massachusetts Boiler Code was passed, all new boilers purchased were constructed in accordance with that code, and when Ohio and Detroit followed with similar special laws, we purchased all subsequent boilers constructed in accordance with those laws in addition to Massachusetts.

In the last year or so the A. S. M. E. Boiler Code has been gaining great headway and several states have adopted it, especially Pennsylvania and Ohio, and the necessity arises of having boilers stamped A. S. M. E. in order to make it possible for us to operate in those states.

We are now facing a situation in which our boilers cannot be stamped both Massachusetts and A. S. M. E., due to a conflict in the codes. In order for us to stamp A. S. M. E. Pennsylvania has already adopted the A. S. M. E. code, and Ohio is going to abandon its own code on Apr. 1 and adopt the A. S. M. E. We are therefore writing to respectfully ask that your influence be exerted with the Massachusetts Board of Boiler Rules, to permit A. S. M. E. boilers to be used in Massachusetts.

THE RAYMOND CONCRETE PILE CO.,
By H. R. Smith.

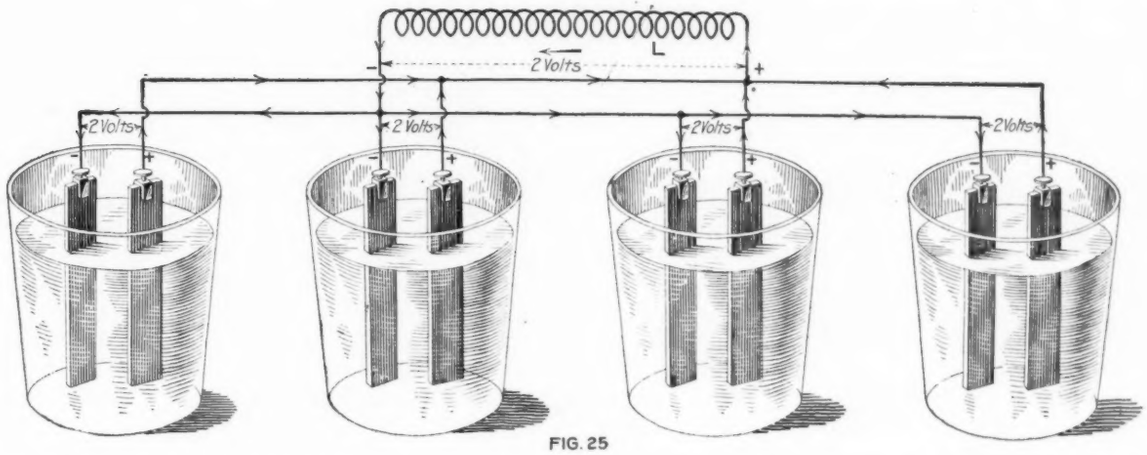


FIG. 25

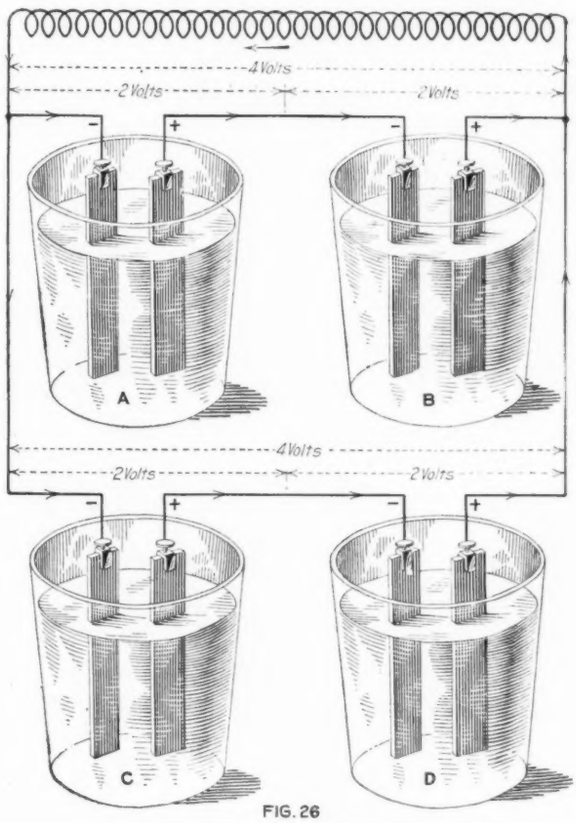


FIG. 26

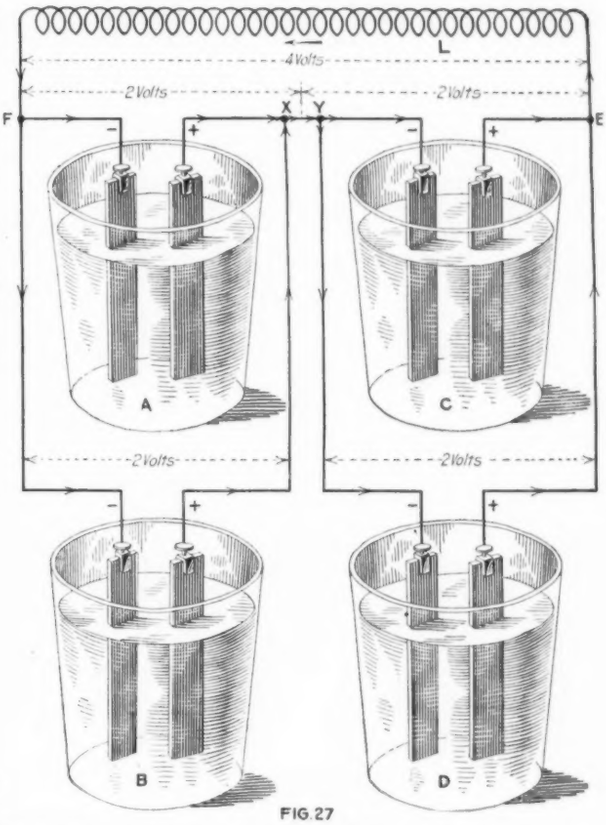


FIG. 27

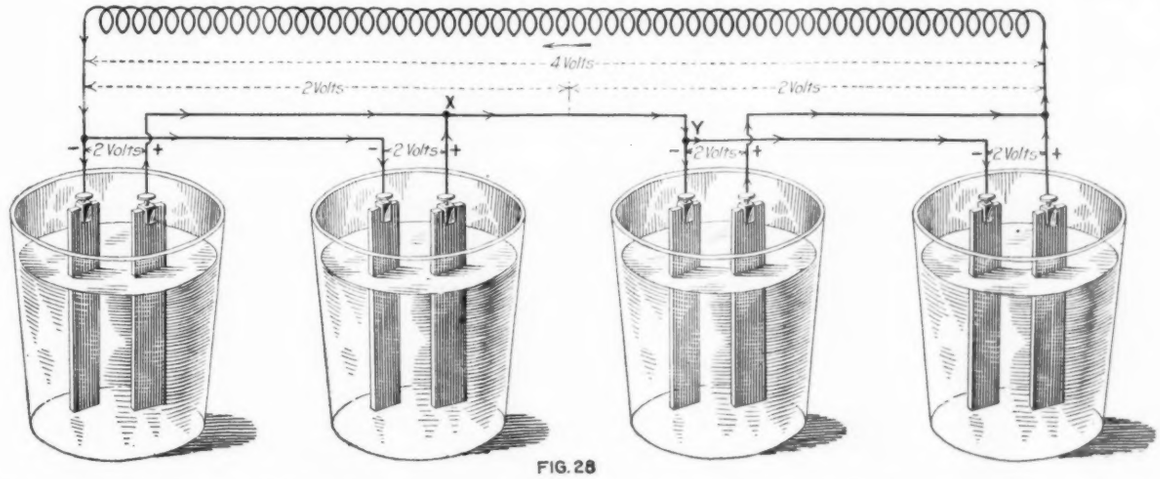


FIG. 28

FIGS. 25 TO 28. FOUR VOLTAIC CELLS GROUPED IN PARALLEL, SERIES PARALLEL AND PARALLEL SERIES
Fig. 25—Parallel grouping. Fig. 26—Series-parallel grouping. Figs. 27 and 28—Parallel-series connection

Visits of Inspector Brown—XXV

By J. E. Terman

SYNOPSIS—The Chief shows Brown how to make a diagram to indicate the bursting and the working pressures of cylinders with seam construction.

As soon as the Chief had finished supper the next evening, Brown reminded him that he had not completed the subject of how to make a diagram to indicate the bursting pressures and the working pressures for cylinders constructed with seams.

"Well," said the Chief, after getting comfortably seated in an armchair, "I was glad last night that you reasoned out how you would make that diagram without reference to the formulas. Where a longitudinal seam is applied to a cylinder, the true bursting pressure is indicated by this formula:

$$B = \frac{T \times t \times E \times 2}{D}$$

where

B = The bursting pressure of a cylinder constructed with a longitudinal seam, in pounds per square inch;

t = The plate thickness, in inches;

T = The tensile strength of the shell plate in pounds per square inch;

E = The efficiency of the longitudinal seam, expressed as a decimal part of one (unity);

D = The diameter of the shell, in inches.

"The figure 2 is used because the diameter and not the radius of the shell occurs in the denominator of the right-hand side of the equation. You understand that the value of T is constant for one particular class of material and in the diagram that I showed you last night (see Fig. 5), 55,000 lb. per square inch was the value used for T. Since the 2 is also a constant, we may multiply the value of T by 2, and the result will be

$$B = \frac{110{,}000 \times t \times E}{D} \qquad (1)$$

You will notice that this formula has no factor in it to represent the bursting pressure of a seamless cylinder, and you will also see that it is not of the form $y = ax$ or $y = ax \pm b$. If you had run across this formula without more instructions about it than you have had, you would think that it could not be represented by straight lines."

"I sure would have, Chief, and I don't see now what you can do with that formula to get it into proper shape for diagraming."

"You will see presently that it is a simple matter to put it into proper shape. Since formula (1) has four variables and we know how to handle only three at one time, something must be done to get rid of at least one. You know, Brown, that this formula (1) may be written

$$\frac{B}{E} = \frac{110{,}000 \times t}{D} \qquad (2)$$

and that the two sides of the equation are equal just the same as in the case of formula (1). Since the two sides are equal, we may assume that their value is equal to any unknown variable, as Z, and formula (2) may be divided into two equations, thus:

$$\frac{B}{E} = Z \qquad (3)$$

$$\frac{110{,}000 \times t}{D} = Z \qquad (4)$$

For any fixed value of Z these two formulas will truly express the relations between the variable values used in them the same as is done by formula (2). For example, assume a value of 1000 for Z and a value of 500 for B, then by formula (3) the value of E would be $\frac{500}{1000}$, or 0.50; that is 50 per cent.

"In formula (4), if D was 60 in. with the value of Z 1000, the value of t would be 0.5454 in., or nearly $\frac{9}{16}$ in. This indicates that for a 60-in. shell a 50 per cent. joint will require a plate thickness of 0.5454 in. in order that the ultimate strength of the shell be 500 lb., provided that the material of which the shell is constructed has a tensile strength of 55,000 lb. per sq.in. The same result would have been obtained by using formula (1), with the same assumed values for the efficiency, tensile strength and diameter. You will note, Brown, that both formulas (3) and (4) are of the form $y = ax$, therefore they may be represented by straight lines that will pass through the intersection of the x and y axes. The only thing necessary, in order to properly

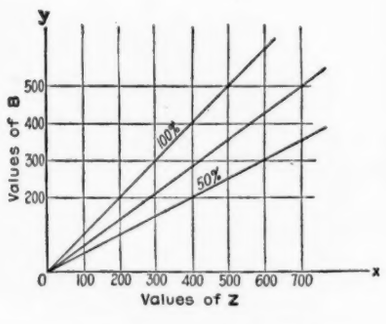


FIG. 1. REPRESENTING THE VALUE OF E

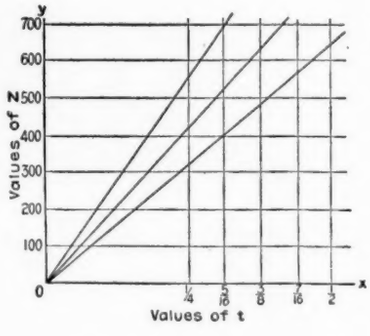


FIG. 2. REPRESENTING VALUES OF D

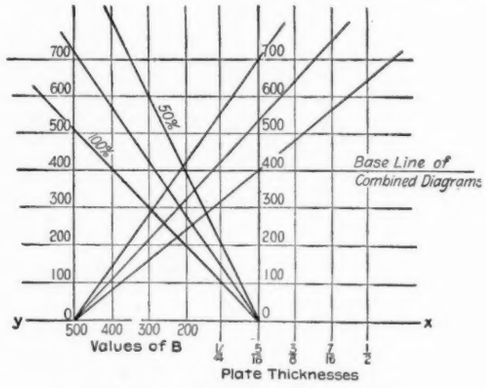


FIG. 3. COMBINING FIGS. 1 AND 2

plot a combination diagram to represent formulas (3) and (4) and have it also represent the values in formula (1) is to see that the values for Z, which are to be laid off on the same line for both sides of the diagram, are laid off to the same scale and from the same zero point.

"To show you that it requires some care to always divide a formula into two parts that may be used in the manner we have discussed, suppose that instead of representing the efficiency E in terms of a decimal part of unity, it was decided to express it as a whole number. That is, instead of 0.60 being 60 per cent., 60 should represent this value. In this case the numerical value of E would be $\frac{E}{100}$ and formula (1) could be written,

$$B = \frac{110{,}000 \times t \times E}{100 \times D}$$

or

$$B = \frac{1{,}100 \times t \times E}{D} \qquad (5)$$

While formula (5) expresses the relations that exist between the variables used in a perfectly proper manner, it could not be divided into $\frac{B}{E}$ and $\frac{1100 \times t}{D}$, as was done in the case of formulas (3) and (4). This is because E in the case of formula (5) does not represent the actual numerical value of the efficiency of the seam as it did in the case of formulas (3) and (4). To divide formula (5) into two parts which would each equal Z and have the relations between the variables in the two parts the same as in the original formula for any particular value of Z, the two formulas would be,

$$\frac{100 \times B}{E} = Z \text{ and } \frac{110{,}000 \times t}{D} = Z$$

To avoid confusion that might arise in this manner, I represented E in terms of its numerical value in connection with this formula (1)."

"There is one thing that I don't see, Chief, in making the diagram you made last night" (see Fig. 5), "and that is, that the lines representing diameters do not come together in a point at the center of the diagram along the base-line."

"I am glad that you have asked about that Brown, for while the explanation is simple, without some instruction, it might not have occurred to you just how this was done. You know that in using this diagram you follow up a vertical line from the bottom on either side and secure an intersection with a line representing diameters or efficiencies as the case may be. The scales on each side of the diagram along the bottom line are entirely independent of each other, and they might be moved any distance apart so long as they were moved on the same straight base-line. The two sides of the diagram might also be moved closer together; in fact, the two sides of the diagram might be plotted one on top of the other if it were not for the confusion that would exist due to the crossing of the various lines. The arrangement used for that diagram is merely for the purpose of economizing space. The base-line is not the x and y axes of the two diagrams, but it is a line parallel with these axes and above them. You will notice that there is no vertical line to represent the common y and x axes of the two diagrams, and if these axes were to be represented, two separate lines would be required. Here, for instance, is the way it is done: The left side of the diagram we are using" (see Fig. 5) "represents the values for formula (3), and we have first to consider what is the smallest value for bursting pressures that will be serviceable. In this diagram 200 lb. as a value for B was taken as a minimum. Drawing the x and y axes like this" (showing Fig. 1), "the bursting pressures are laid off on the axis of y, the first horizontal line being at a distance above O representing 200 as a value for B. The values of the unknown quantity Z are laid off on the x axis, and while it is not at all necessary to have the scale for these values the same as for those on the y axis, making them to the same scale will result in a good angle for the lines representing the different values of E. With the two scales equal, the line representing a 100 per cent. value for E will be at an angle of 45 deg. with the two axes. The other efficiency lines will be at smaller angles with the axis of x here. Now,

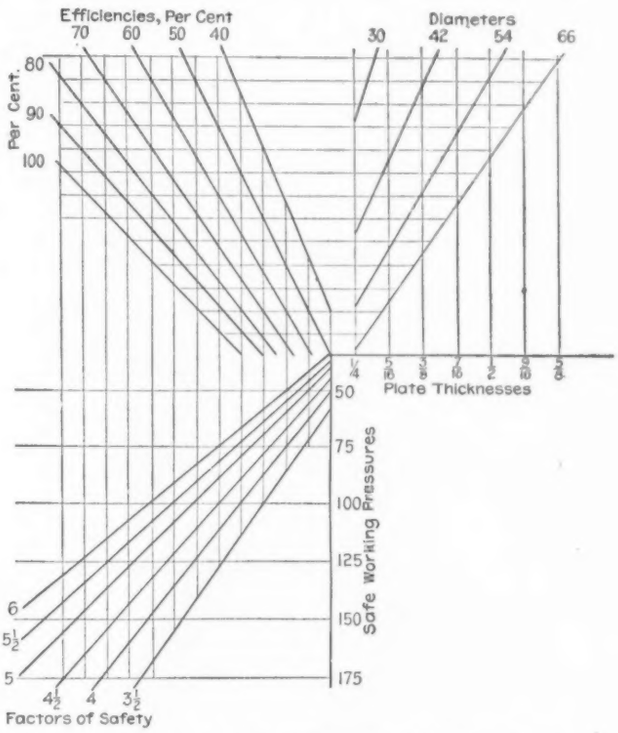


FIG. 4. DIAGRAM OF BURSTING PRESSURE FOR STEAM BOILERS

Brown, you can see that these lines representing the values of E will all pass through O, this fact being indicated by formula (3), which they represent when written in the form $B = EZ$.

"The right half of this diagram" (see Fig. 5) "was laid off like this," (showing Fig. 2), "but since we did not care to consider values for plate thicknesses lower than ¼ in., no vertical lines closer to the y axis than would be required to represent this plate thickness are drawn. The lines indicating the different values of D all pass through O as indicated by formula (4) when written in the form, $110{,}000 \times t = DZ$, the same as with the case of the lines representing efficiency values for the other side of the diagram. Now you must remember, Brown, that the divisions to represent the values of Z in both of these diagrams" (Figs. 1 and 2) "must be to the same scale, otherwise they could not be combined into one diagram. In placing these two diagrams together, instead of the axes of x and y being placed

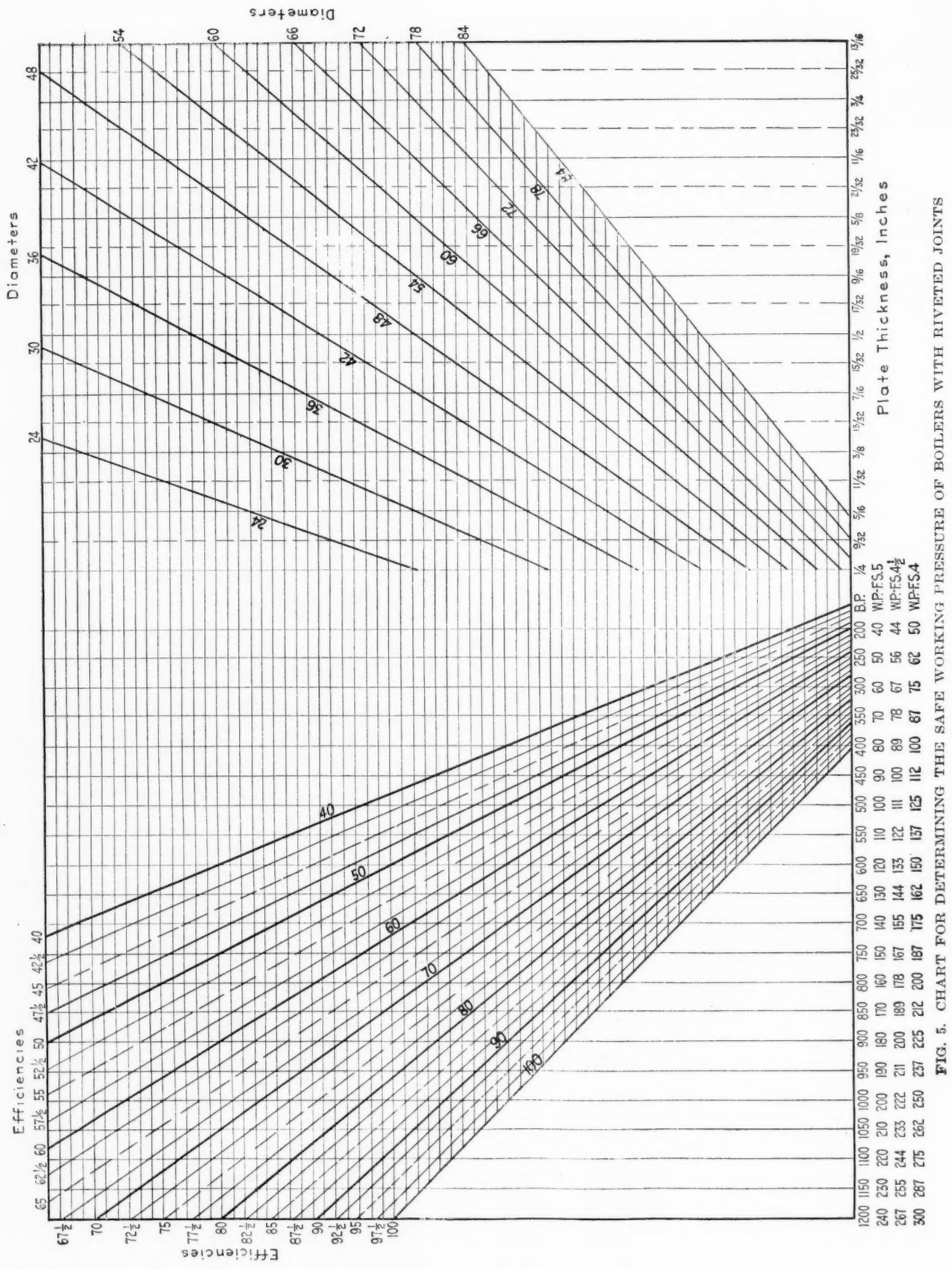


FIG. 5. CHART FOR DETERMINING THE SAFE WORKING PRESSURE OF BOILERS WITH RIVETED JOINTS

together so as to coincide, they are arranged thus" (Fig. 3); "that is, the two axes of x and y overlap and the other axes of y and x are placed so that they coincide with the same horizontal line. This method of arrangement economizes in space by removing a portion of the midsection that is of no value in using the diagram. The base-line of the diagram is raised to a point representing a value of 400 for Z. That the base-line on this diagram" (Fig. 5) "has been raised to this point can be seen by noting the intersection of the 100 per cent. line with the

base-line. It is seen that this line cuts the base-line at a value of 400 for B, and the values of B and Z must be equal at 100 per cent., for the numerical value of E is then 1, and this equation (formula 3) would become $\frac{B}{1} = Z$, or $B = Z$.

Position of Intermediate Lines

"You will remember, Brown, that in drawing the original diagram for the bursting pressures of solid cylinders," see Fig. 5, "it was found to be necessary to locate only the position of the diagonal lines representing the largest and smallest cylinder diameters to be considered and obtain the position of the intermediate lines representing diameters by dividing the distance between the intersections of these lines with a horizontal line into equal spaces. You will remember that the number of such spaces was one less than the number of diameters considered. Do you see any way by which the positions of the lines representing the values of E in the left-hand side of the diagram might be obtained in a similar manner?"

"Why, yes, Chief, I have been thinking about that matter since you split formula (2) into the two parts, formulas (3) and (4). I can see that the same reasoning would apply in the case of formula (3) as it did in the case of the previous formula used in the diagram for the bursting pressures of solid cylinders. If this formula (3)," continued Brown, "is written $B = EZ$, since each increase in E is to be the same, 2½ per cent., for any constant value of Z, the increases in the value of B would be equal. Therefore, it would only be necessary to locate the lines representing the maximum and minimum values for E to be considered and divide the space on any horizontal line intercepted between these lines into even spaces, one less in number than the number of values of E to be considered."

"Correct, Brown. I am certainly glad to see how well you are taking hold of the problems connected with the diagraming of formulas. We will be able to tackle that problem of diagraming the values represented by the formula in the A. S. M. E. Code for stay-bolt spacing, as our next lesson."

"I will be glad of that, Chief, but I already have something to think over. I intend to put into practice at once what you have shown me about these bursting-pressure diagrams, for I intend to make one for Casey's foreman. On this diagram, Chief, I think I will attempt to include the third section that you were talking about last night, so as to indicate the working pressures direct for any factor of safety. Is the formula $\frac{B}{F} = W$ correct for making this third section of the diagram, where B is the true bursting pressure, the same as you have assumed it, F the factor of safety and W the safe working pressure?"

"Why, yes, Brown, that is certainly the correct formula; the true bursting pressure of a cylinder constructed with a longitudinal seam divided by the factor of safety must give the working pressure. The diagram you intend to draw, when completed, will look like this," said the Chief, drawing Fig. 4.

"I will surely make one of those diagrams for Casey's foreman, Chief. All that he will have to do is to follow straight lines around from plate thickness to working pressure or from working pressure back to plate thickness."

"Well, Brown, that sounds easy, but if Casey's foreman is not in better condition than when I last saw him, he won't be able to follow anything that is straight. There is one thing that I believe I did not mention to you before, Brown, and that is, that the plate thicknesses could have been indicated in decimal parts of an inch instead of in fractions, and intermediate values could have been read more readily. However, I feel sure that you will find the fractional divisions more convenient for your work. I will prepare some diagrams of the stay-bolt spacing formula when I get back to the office. We will probably learn a new wrinkle when we go thoroughly into that problem."

"All right, Chief. I will be with you when you give the word," said Brown.

Garland Flue-Gas Analyzer

For the analysis of flue-gas samples some form of Orsat is desirable that is portable, accurate and not readily broken. An apparatus which would appear to meet these conditions is described herewith. Fig. 2 illustrates the sampling apparatus as applied to one or more boilers.

This apparatus consists of a plurality of small sampling tubes which extend to different points across the setting,

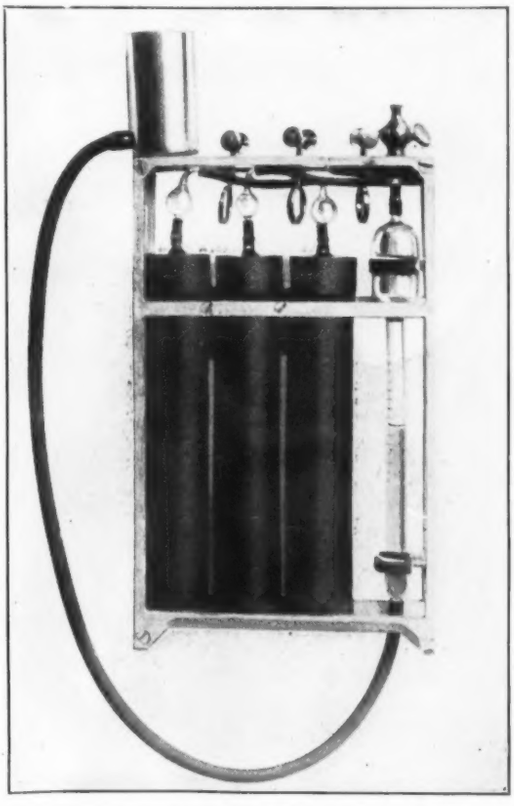


FIG. 1. DETAILS OF THE CO_2 ANALYZER

the ends of the tubes being spaced approximately 18 in. apart so that samples of gas are taken at intervals across the furnace width. The tubes communicate through graduated openings with a header, which is mounted on the side of the setting. The graduated openings into the header are such that the same quantity of gas is drawn through the short tube from the near side of the

setting as is drawn through the long tube from the far side of the setting. The header is provided with a removable cover so that the tubes may be scraped out from time to time. A steam line communicates with the header, and a valve is placed in the gas line below so that the sampling tube may also be cleaned occasionally by blowing out with high-pressure steam.

To prevent the small pipe leading from the sampling tube to the aspirator becoming clogged with soot, a gas filter is placed in the gas line from each header.

A steam-jet aspirator is provided for drawing a continuous sample of gas through the sampling tube from each boiler, and a gas collector is used for drawing and storing a continuous sample of the gas passing from each boiler to the aspirator.

The gas collector is designed to draw out the gas sample at a uniform rate. The collector consists of a cylindrical vessel of shallow depth provided with a gage-glass, gas connections, a water inlet for filling and a water leg to which is attached a sight-feed device.

The operation of the collector is as follows: The valve in the connection for the Orsat is opened, and water is admitted through the water inlet until the gage-glass is filled. The valve to the Orsat is then closed. Previous to the filling with water, however, a small quantity of oil is placed in the collector. The oil forms a film on the surface of the water to prevent the absorption of the gases. After the collector is filled, the sight feed is adjusted to empty the collector in a given time, 8, 10 or 24 hours, as the case may be.

Owing to the shallow depth of the collector and to the distance between the bottom of the collector and the sight feed, there is practically a constant head on the sight feed, so that the flow is to all practical purposes constant. A uniform sample of gas is therefore drawn into the collector.

The Orsat is especially adapted for boiler-house conditions. Fig. 1 shows the general arrangement. It consists of a bi-part aluminum frame in which are gripped the pipettes and the burette. The pipettes are

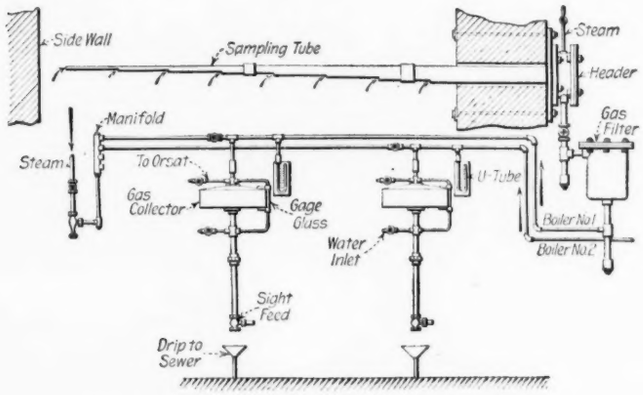


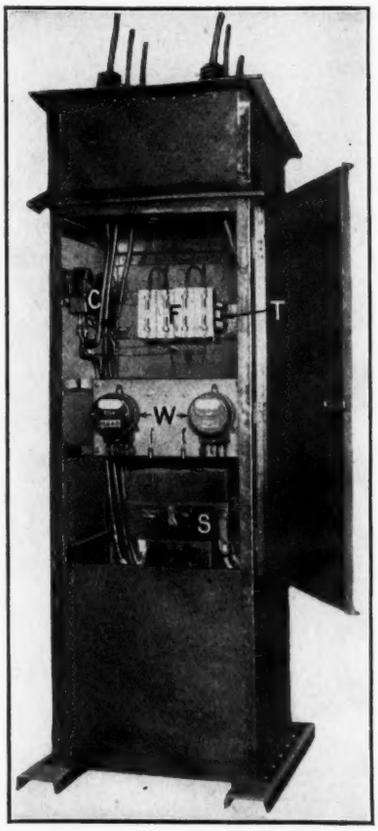
FIG. 2. SAMPLING APPARATUS AS APPLIED TO A BOILER

made of a nonfragile composition which is chemically inert to the absorbing fluids. At the top of each pipette a sight glass is used to indicate the level of the fluid. Fig. 3 shows a section through one of the pipettes.

The Orsat is provided with a leather waterproof-lined carrying case. The outfit is made by the Ensign Instrument Co., Chicago.

Outdoor Switchhouses

The development of transmission- and distribution-line networks all over the country has brought about many problems for the operating man, among which is the economical supplying of power to small towns, manufacturing plants, mines, etc., from high-voltage circuits, where the load is not large enough to warrant the expense of a permanent substation building and indoor apparatus. To efficiently meet these requirements the large electrical manufacturing concerns have developed a portable switchhouse such as shown in the figure. In general, the standard types are built in two forms — ground mounting and pole mounting. The use of the houses has given such satisfaction that the tendency is toward an increase in their application as well as in their size and capacity. These houses are constructed of steel throughout and are usually designed to contain an oil circuit-breaker *S*, watt-hour meters *W*, current transformers *C*, and potential fuses *F*, mounted on the voltage transformers *T*, besides calibrating and testing terminals and the usual wiring. Their cheapness and the fact that they can readily be conveyed from one locality to another wherever needed, makes this type of switchhouse particularly suited for the purpose for which it is intended. This equipment makes it possible to supply small plants that it would be impossible to reach otherwise, on account of the high cost of substation construction. Standard equipments are built in capacities up to 600 amp. at 7500 volts, for both single- and polyphase circuits. The usual dimensions of such houses are 3 x 3 x 10 ft. high, although some special houses are being built in much larger sizes. The general trend of recent practice in this type of switchhouse construction is shown by the fact that a contract has recently been taken by the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Penn., for a house 10 x 10 x 10 ft. high for 4000-kv.-a., 13,200-volt three-phase 60-cycle installation.



INTERIOR VIEW OF SWITCHHOUSE

FIG. 3. PIPETTE

Editorials

Meeting of the Boston Section A. S. M. E.

As stated elsewhere in this issue, the Boston Section of the American Society of Mechanical Engineers will hold a meeting Thursday, April five, afternoon and evening, and possibly Friday, the subjects to be central power stations, municipal electric plants and independent plants. The local committee in some of its announcements stated that the purpose of the meeting is to discuss the relative merits of the different kinds of plants.

Surely the subject affords a fruitful source of discussion. There is no body of men more competent to deal with it than the American Society of Mechanical Engineers. Through no class is the subject capable of being given a broader, fairer and more comprehensive expression. There has been altogether too little of the unbiased scientific in the literature and comments relative to the respective merits of service from each kind of plant. Very often the central-station proponents have allowed their enthusiasm to carry them beyond where their better engineering judgment would have halted. The operating engineers have, on the whole, been too sweeping in their condemnation of central-station service and sometimes too unmindful of fact in their defense of some isolated plants.

We see the central stations exceptionally well organized to promote the industry. There are several committees for this purpose in the National Electric Light Association; there is the Society for Electrical Development, and the Association of Edison Companies, to mention only a few of many. Happily these organizations do much to promote engineering. The central-station interests make use of every excellent advertising opportunity, and rightly. Who is not familiar with the huge electric signs on new structures announcing to the thousands who pass daily that central-station service is used in these buildings? Each large lighting company has its attractive house organ. It is only good business to use every legitimate means of widening their field. It is regrettable that there is not a proportionate amount of like effort by those whose interests are in the isolated plants. Unfortunately, we see the largest educational organizations of operating engineers doing nothing specific in this direction, other than the comparatively meager amount of general educational work which they carry on. Such work, if properly financed, systematized and vigorously pursued, would bring the greatest returns.

We hope to hear some valuable discussion at Boston next month. The underlying thought in every discussion should be that the question of which particular kind of service is best for any particular condition is an engineering one.

Boston is a particularly fitting place for holding such a meeting. It is the center of one of the oldest and largest industrial sections in the country, which abounds in excellent types of central, municipal and isolated power plants. All will expect much from the local committee.

Evaluating Education

It is claimed by some that all the geometry an engineer needs can be acquired in a few lessons and that additional time devoted to the subject is useless so far as commercial and technical demands are concerned. Moreover, mathematics taught purely for the sake of mental discipline is held in some quarters to be unwarranted, for the reason that a student's time can be otherwise employed to better purpose.

What subjects ought to be taught in our schools and colleges and how may they be taught most effectively are questions seriously asked today in educational circles. The engineering profession stands unequivocally for technical education, holding that the fundamental requirements of the profession cannot well be acquired by the old apprentice system. And yet even our best technical institutions are occasionally made the objects of adverse criticism that knows not meet nor bound. Some years ago an honored citizen of Chicago, a wealthy and successful manufacturer of wide experience and observation, instituted a propaganda against schools for technical instruction. In a widely circulated pamphlet he held that "the common-sense method of making electrical engineers" was not to send boys to technical institutions "that know nothing beyond what the practical man has taught them," but instead to put them through the various grades and departments of a well-equipped machine shop, supplementing the instruction so obtained, when necessary, in a night school. He questioned "the utility of technical schools even for making the very best civil engineers." "College authorities," he said, "are sharp practice men" who set about to deliberately defraud the public.

Absurdly ill-chosen words are these; yet they do give expression, rudely to be sure, to prevalent though ill-defined convictions that the finished product of our institutions of learning is lamentably and unnecessarily defective.

In the hope of locating and defining some of these defects and shortcomings and of suggesting likely ways of overcoming them, so far as this may be possible, two powerful educational agencies are now actively and resolutely at work—the Carnegie Foundation for the Advancement of Teaching, and the General Education Board founded by John D. Rockefeller. At present, the former is making a special study of engineering education. Among other questions it is asking and endeavoring to answer are these: What are the qualities that count most in engineering success? In point of importance how and in what order should these qualities be rated? A canvass of over six thousand practicing engineers showed conclusively that in the opinion of the profession the qualities desirable and the order of their importance, based on a scale of 100 points, are about as follows: Character, 24; judgment, 19.5; efficiency, 16.5; understanding of men, 15; knowledge of fundamentals, 15; technique, 10.

This statistical showing was unexpected, for it discloses the fact that out of 100 points, human qualities, desirable in any relation of life, commanded 75 points, while knowledge of fundamentals and technique combined commanded but 25. This showing has been a revelation in engineering circles, and the schools will surely take note of it, for they have been devoting their energies almost wholly to the technique of the profession rather than to the human elements that make so decidedly for ultimate success.

The General Education Board, in conjunction with the Teachers College at Columbia University, is soon to undertake a radical experiment in education. Preconceived ideas and traditional notions are to be thoroughly tested and eliminated if found wanting. Programs of study and methods of instruction are to be tested for specific results with the rigor and exactness of modern science. No unfounded assumption, however time-honored or sacrosanct, will be allowed to pass unchallenged. Every subject of study and every method of presentation and procedure will have to show cause why it should obtain. This work is undertaken under the conviction that much educational work is formal and traditional, its worth to the individual and to the state never having been challenged under circumstances competent to determine its value as a factor in the production of character on the one hand or economic efficiency on the other. Merely because a subject has long held an established and honored place in a curriculum is no proof that it should not be eliminated.

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Can the Public Be Just?

In these days, when the public through its representatives, the public-service commissions, can question what is and what is not a just and adequate service rendered by a utility company and what is a commensurate return on a reasonable capital investment to render the service, the question arises, "Can the public be just?" A review of the many decisions by courts and public-utilities commissions indicates that there are sufficient precedents to answer this question in the affirmative, especially where the public has not been prejudiced by treatment at the hands of a utility company before being given the wherewithal to contest the service rendered.

The fact that the minimum charge for an electric service, when supplied according to a meter rate, has in general been upheld by public-utility commissions and courts whenever they have been called upon to render decisions upon the reasonableness of this charge is only one of many indications that the public wishes to be fair.

If the public wants the service, it is willing to pay a fair price for it. This has been manifested time and again. Probably one of the most notable examples of this was the case of the Hudson & Manhattan Railway Co. When it found that adequate service could not be rendered over its lines connecting uptown New York and Jersey City on a five-cent fare, the public was induced to agree to a seven-cent rate. But this was gone about in the correct way; service was first rendered at a price that the public had been used to paying, and then the company proved that it was impossible to maintain this service at the usual price.

The sustaining of the summer differential rate in Massachusetts last year by the Massachusetts Gas and Electric Light Commission is another demonstration that at least the representatives of the public can be fair. In this case the company supplied service to an island colony where the summer-residence service constituted the greater portion of the load; which determined the size of the station and distribution equipment. It was the opinion of the commission that since the summer load determined the size of the equipment and consequently the investment, the utility was justified in giving a 60 per cent. reduction in its residence-lighting rates from October to May over those of the summer months.

In a town in Idaho, after a utility had at considerable expense established an electric service, a movement was started by outside interests to reduce the rates, but the public refused to countenance any interference with the company's rates and policies on the ground that the former had made a considerable investment to render the community a satisfactory service and was therefore entitled to enjoy a reasonable return on the investment.

There are utilities that are being closely regulated and are feeling the effects of such regulation—notably the trunk-line railways. But here it is not so much close regulation as it is that the public has refused to be forever burdened with the expense of the early-day railway stock manipulations.

The attitude of the public toward a utility is determined largely by the attitude of the utility toward the public. If a utility assumes a public-be-damned policy, rendering adequate service only when forced to do so by the courts, and would sooner spend money in trying to avoid its obligations than in fulfilling them, it cannot expect to create a favorable public sentiment. On the other hand, if a public-service corporation considers that the public, as well as itself, has certain rights and assumes that its duty is to render a just service at a fair profit on a reasonable investment, the public in general can be trusted to be just and the utility has nothing to fear.

Five years ago, in general, public-service corporations were opposed to commission control, yet today their attitude is in most cases favorable to such regulation. This change of position on the part of the utilities never would have come without an awakening to the fact that the public can be depended on to reciprocate a fair policy.

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Considerable interest attaches to a suggestion by F. Huntington Clark, a mining engineer, that the U-boat blockade be met by the construction of a large number of relatively small cargo carriers, say about two thousand tons, constructed of wood and propelled by internal-combustion engines either of the Diesel, semi-Diesel or gasoline types. There appears much to commend the plan. The yards building steel vessels are already overcrowded whereas there are many yards along the Pacific and the New England coasts equipped to turn out at short notice wooden vessels of this type, and cheaper than steel ships. The value of the wooden ships after the war would not be an important factor as one or two trips at the present freight rates would cover the first cost. Moreover, the chances of getting shipments through the war zone when split up into a large number of relatively small units are far better than when contained in a single large cargo which one torpedo may send to the bottom in a few minutes. Lastly the project holds promise for greater activity in the oil engine business, as it is likely that semi-Diesel engines would best fit the conditions.

Correspondence

A Central-Station Viewpoint of an Isolated Power Plant

I have been interested in reading the article written by Julius G. Berger, appearing in the Jan. 30 issue. While the writer of this article has given in an able manner the method of analysis and the conclusion which can be deduced therefrom, he has passed over too lightly the prime element in the cost of power which the manager or owner of a manufacturing plant considers more carefully even than the actual comparison of costs as suggested by Mr. Berger.

The element that has oftener than any other decided the power user for central-station power is the consideration of the value of capital. Not only the manufacturer "who is short of capital," but some who have at their command unlimited resources use central-station power, notwithstanding the fact that actual generating costs from a private plant are less than the same energy purchased.

The willingness of such manufacturers to purchase power is due to a large extent to the uncertainty of the period during which power may be required, under the conditions existing at the time when the decision is made for or against a private plant.

It is therefore the "fixed charges," which involve the rapidity of returning invested capital "by writing it off," which make the controlling element in the mind of the present-day manufacturer. I prefer the term amortization to "depreciation," although the latter is most frequently used to designate the probable useful life of a generating plant in the factory. The manufacturer would rather "play safe" at the expense of a possible greater operating cost than to tie up in a fixed plant any considerable amount of money that could otherwise be turned over at a higher return for its use.

Newark, N. J. H. H. Holding.

Trouble from Hard Water in Boilers

In reply to George Smith's letter in *Power* of Feb. 13, "Trouble from Hard Water in Boilers," I would call attention to the fact that hundreds of people are having the same trouble. In the first place they have bad scale or they would not buy a water softener. It does not seem to be generally understood that with a hard lime water it requires a large amount of lime and soda ash to prevent scale forming. Compound is used not to get rid of scale, but to prevent scale from forming.

Now, when this is successfully done, instead of having scale you have mud (soft lime) as well as the quantity of compound fed into the system, to be removed; and if it is not removed before it enters the boiler, it must be afterward or else there will be foaming, which means this soft lime and compound is carried with the steam into the steam lines, causing the trouble described by Mr. Smith, as well as filling steam traps and lines with this sludge, or soft lime.

The fact that Mr. Smith has this trouble with lime in the turbines shows that he is treating the water correctly and, as he says, the less scale he has in the boilers the more lime he has in the turbines.

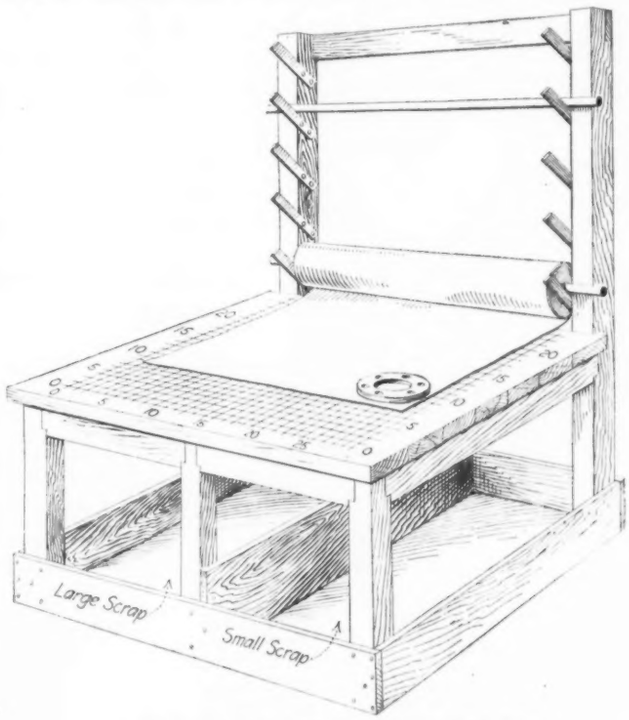
Hard boiler water, when properly treated to prevent scale, soon accumulates more sludge (soft lime) than the water will carry. The ordinary water will not carry more than about 300 grains per gallon before it saturates the steam, with the results described.

If Mr. Smith will provide for the continuous removal of this lime sludge from the boiler, he can bring the water by treatment to as low as three degrees of hardness, which will reduce the scale to a satisfactory degree, and he can then run his boilers longer intervals between washings and not have any lime trouble.

Elgin, Ill. E. H. Reiter.

Rack and Bench for Packing

The illustration shows the construction of a bench for sheet packing, which is particularly useful in small plants purchasing from a distance and in large plants keeping a supply independent of the main warehouse. Several



SHEET PACKING KEPT READY FOR USE

kinds and thicknesses can be kept on the rack and the desired packing pulled out on the bench and cut to size, using a straight-edge and the scale of inches marked across the bench. In case of small flanges that can be brought in, the bench is made heavy enough so that the packing can be cut directly from the flange either by marking or peening. The under part of the bench is di-

vided into two compartments, one for large and the other for small scraps. J. N. BOYCE.

Anaconda, Mont.

Flow Over Sixty-Degree Notch

The statement on page 863, issue of Dec. 19, 1916, that the flow of water over a symmetrical notched weir in thin plate is substantially the same for 60 deg. and 90 deg. and is given by the formula, $Q = 2.54 \times \sqrt{h^5}$, is probably an oversight or typographical error. The formula is correct for a 90-deg. notch, but the flow must vary with the width of the notch and is substantially proportional to the tangent of one-half of the angle. There also is a variation of the coefficient for different values of h and for different dimensions of the weir chamber. At the meter-testing laboratory of the Harrison Safety Boiler Works, where the notches used in Cochrane V-notch meters are calibrated, tests have been made on notches larger and smaller than 60 deg. and by interpolation of the data the value of the coefficient for 60 deg. would be 1.459. G. H. GIBSON.

Philadelphia, Penn.

[The item referred to was incomplete and should have read: The flow of water over a symmetrical notched weir in thin plate is substantially the same for 60 deg. and 90 deg. and the flow in cubic feet per second is given by the formula $Q = C \times \frac{8}{15} \times \frac{lh}{2} \sqrt{h}$, where C = a constant = about 0.59; l = width in feet of notch at the height h above the vertex; h = head of the water above the vertex. The flow for a 90-deg. notch in which $l = 2h$, is given by the formula $Q = 2.54 \times \sqrt{h^5}$. By similar interpretation, the value of the coefficient for a 60-deg. notch would 1.466.—Editor.]

Do Blowers Cause Clinkers?

The trouble with hard clinkers, to which Mr. Gibson refers in the issue of Feb. 13, page 229, is no doubt brought about by the blowers. As he says, they were installed to increase the steaming capacity of the boilers, and necessarily the temperature of the furnace is increased, which will have a greater fusing effect on the ash, and there will also be a greater consumption of fuel per square foot of grate, with a greater accumulation of ash in a given length of time. With the increased rate of combustion it will be necessary to clean fires oftener, both to keep a clean unobstructed fuel bed and to prevent as much as possible the fusing of the ash.

The exhaust steam from the blower mixing with the air should not cause the clinker trouble, but rather overcome it by the moisture carried to the ash on the grates. Many firemen keep water in the ashpits of hand-fired furnaces to prevent the ash from clinkering.

One thing that causes troublesome clinkers to form, especially when a fire is forced, is the improper use of the slice bar. Some firemen will persist in running the bar under the fire and then bringing it up through the bed of coke and coal. This carries more or less ash and small clinkers up into the hottest part of the fire, where it is fused. It then runs down through the fire and ash, binding all together, and the more the fire is barred the worse the condition becomes. The proper way is to run the bar under the fire bed along the grates, work it sideways to clear the fine ash out through the grates, then with an up-and-down movement, just enough to break the fuel bed without carrying the ash and clinkers into the fire.

If a large clinker forms, it can usually be turned up through the fire with the bar and pulled out with the hook or rake. E. PALMER.

Philadelphia, Penn.

An Operator's Oversight

Referring to the article, "An Operator's Oversight," in *Power* of Feb. 6, page 192, the company I am employed by has a short and ground system at each generating station and some of the substations; also, each lineman has a chain to short and ground the line before doing work on it.

When an operator kills a circuit, he shorts and grounds it; if the substation at the other end is equipped, the line is also shorted and grounded at this end. The operator then reports the line killed, shorted and grounded. If not grounded at the substation, the linemen are ordered to place their shorting and grounding chain on the substation side.

If everyone adheres to the rules, there is little danger of any accidents. It takes a little time, but is "safety first." L. W. RAGSDALE.

Milton, Ore.

Gasoline Specifications

The question of satisfactory fuel for automobile engines has become serious from the viewpoint of the consumer. The fluid sold as gasoline has steadily deteriorated in quality and increased in price during the past several years, and all efforts to ascertain the real reason have come to nothing.

During 1915 the Bureau of Mines carried on an investigation of the gasolines then on the market, the investigation consisting of tests to determine the volatility and specific gravity, and the results of these tests (published in Technical Paper No. 163 and abstracted in the Feb. 6 issue of *Power*) are of great interest to the chemical engineer. So far as the general public is concerned, however, they are useless, and the "Suggested Specifications" for the purchase and sale of gasoline, on page 38 of the Bulletin, are perfunctory and confusing. In the first place no specifications are given; in the second, the limited advice proffered reminds one somewhat of the Irishman's horse which died just when he had learned to feed on shavings instead of hay and grain.

The question of specifications for the sale of gasoline has been taken up by a committee from the Bureau of Standards and the Bureau of Mines, and it is to be hoped that some intelligent system of dealing with the subject will be evolved. The committee's suggested criterion of two temperatures—those at which 20 per cent. and 95 per cent. of the gasoline will volatilize—is rather academic and unintelligible to the average consumer. Moreover, it would be necessary to specify the apparatus and method to be used in distilling the gasoline. It would seem to be much better to specify the proportion of gasoline that would be distilled at two given temperatures, using any simple standard apparatus for distillation; the temperature at which volatilization is desirable may be readily

ascertained, and the gasoline that yields the most distillate at that temperature is obviously the best for that purpose.

For the last year the City of Atlanta has purchased gasoline on the basis of a distillation temperature of 100 deg. C. The bidders submit samples, and the sample that yields the most distillate up to 100 deg. C. is considered the best. If there is any difference in bid price (there has not been, so far), each bid is divided by the square root of the proportion of the corresponding gasoline which comes from the still up to 100 deg. C. and the result is considered the *comparative* bid price. The gasoline that shows the lowest comparative bid price is accepted.

Deliveries of gasoline are also tested by distillation and penalized if they fall short of the record made by the bid sample. The correction is made by applying the ratio of the cube roots of the bid-sample percentage and the delivery-sample percentage to the price; that is, the actual payment price is equal to

$$\textit{Contract price} \times \sqrt[3]{\frac{G_d}{G_b}}$$

where G_d represents the percentage of the delivery sample that distills over at 100 deg. C. and G_b the percentage of the bid sample that distilled over at that temperature.

Of course we realize that this is a rather arbitrary and crude method of adjustment, and it is to be hoped that some procedure more scientific in character may be evolved by the committee previously referred to; unquestionably it is necessary to make an adjustment in price to meet divergencies from contract guarantees.

CECIL P. POOLE,
City Mechanical Engineer.

Atlanta, Ga.

Changing a Hot-Water Heating Job to Steam

If a hot-water heating system proves inadequate, from insufficient radiation or increased leakage or infiltration of air as the building gets old, it is an easy matter to correct the trouble by introducing steam in place of the water into the radiators, direct or indirect. This change does not involve as much difficulty, as a rule, as one might suppose. It is true that the mains, flow and return, are usually much larger than would be used for a steam job, but if the part of the building through which the piping passes is "underheated," the large pipes will help by giving off more heat; otherwise, better covering should be provided.

The process of changing over consists in draining out the water and following it with the steam at the same time. This plan detects at once the radiators that are likely not to drain well or to set up water-hammer. It is probable that in a direct heating job no serious trouble will be met with from the upper floors, but sometimes those in the basement or on the boiler floor will need to be drained by a pump or may even call for a separate return, but not often. Keeping in mind that radiators of the hot-water type will work quietly even when partly filled with water, because of the top inlet, makes the job less "fearsome," and those in the basement may give off enough heat when entirely filled with water as originally intended, by the help of the extra radiation from the pipes, while those on the floor above are steam dry. The water level can be maintained anywhere between the basement floor and ceiling by the correct location or elevation of the steam trap, taking care to connect a pipe from a dry steam line to the inlet pipe to the trap where it connects to the trap.

If no radical changes in piping are required, it is a good idea to retain all the essential features of the hot-water job so that water can be used in mild weather and steam during extremely cold snaps. J. LEWIS.

One Feature of Oil Burning

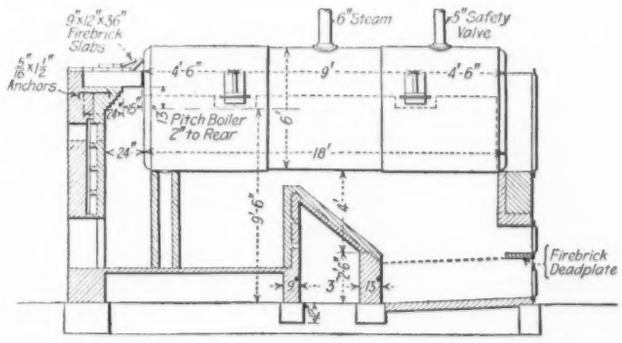
The use of fuel oil has changed the duties of firemen considerably, and there are to be found many young men who, though physically incapable of operating hand-fired boilers, adapt themselves to the use of fuel-oil apparatus, after a period of instruction.

Many young men ambitious to become engineers quit, not having the necessary physical strength to work up through the fireroom. Oil burning has added a great deal to the attractiveness of power-plant work as a vocation for young men. H. C. WILLIAMS.

Concord, N. H.

Return-Tubular Boiler Setting

The letter on "Holding Rear Arch Brick," page 598 in the issue of Oct. 24, 1916, prompts me to illustrate the rear-arch construction that we have been using for the past six years successfully. There is more or less trouble with any arch construction in which metal is exposed directly to the gases of combustion. The arch



SPECIAL REAR-ARCH CONSTRUCTION

shown has no metal exposed to the heat. The large firebrick block is laid up to within about one inch of the rear head, and the small bricks lean against the head at an angle of about 45 deg. This row of brick simply rises and falls with the movement of the boiler, at all times keeping contact with the boiler, which is sufficient to make a fairly tight joint. This construction is comparatively cheap and allows room to roll the upper flues, which is not the case with many settings. It is our practice to set boilers, as shown, 4 ft. above the grates in order to give a large combustion space for burning soft coal. We also lower the cast-iron dead-plate about 3 in. and use No. 1 firebrick on top of it for a covering. This has proved very satisfactory, as it prevents the dead-plate from warping, and although the bricks crack and

wear away, they do not have to be replaced as often as one would think. Then, too, the replacement is an easy and cheap operation. T. B. Wood.

Chambersburg, Penn.

The Coal Problem of Today*

Referring to the letter by Mr. Gould on the coal problem, I would say, as to the quality of coal, that some mines do produce good fuel and some dealers try to procure it for the consumer, but they are up against it, and as a result we get a fuel that has been reduced in size several times, with a large percentage of foreign matter added that years ago was thrown to the culm dumps, and at an increase in price. The consumers would be the gainers if the coal operators would charge for the additional weight of refuse and never ship it at all, as there is nothing in it to generate steam and it certainly makes trouble in the furnace. It does not require a chemist's or an expert's knowledge to find this out. The culm that has for the last few years been introduced into the fuel was bad enough without the addition of more bone and slate. The large culm banks are rapidly disappearing, and we have paid the price.

Again, what about the tons of water that are sold because of the present method of preparing the fuel? Who is paying for water at coal prices? The consumer.

During the last 12 years I have tried several fuels and from as many different dealers; some of the coal was very good, and could we now get it, we certainly should do so. We run daily tests, weighing the fuel and the ashes on the three shifts, metering the evaporation, obtaining CO_2 records, draft records, steam recording charts, smoke charts, total output, readings and many other records—not for one day, but for every day.

I have access to the State Chemist, whose office is in our building, and at times have checkings of our fuels made, but we count more on what our results tell than on what he can tell us. In fact, some time ago he stated that the only thing he could do would be to tell in advance what there was in the fuel, and then it would be up to me to get it. There are men who are assuming to tell us what to do and how to do it, but for all that the fuel, the load and the man with the shovel is the only satisfactory combination to use in finding out. There are cases where the expert can help, but there is some factor lacking.

As to guarantees, what use is there in asking any dealer to guarantee anything? Not the slightest, because none of them will make them. We certainly would not accept such fuel as we are now getting if we could help it. We may not be forced to take it, but with the market as it is, what else can be done? Most of our large dealers do try to furnish good fuel, but they cannot get it. Furthermore, dictating to the coal dealer or producer is a different proposition from "handing it" to the butcher.

The solution of the fuel question may be in the hands of the consumer, but I doubt it. A representative of a coal company called to interest me in their fuel, some of which I had used before. I said that I would like to use some of it, but that it ran too high in ash. To this he said, "Well, what are you going to do if it is half ash?" I did not use this fuel, and how much more could the expert do? I believe that conscientious men working like mine do for the interests of the plant is the better way.

*See "Power," page 162, Jan. 30; page 264, Feb. 20, 1917.

Finally, if the coal problem was in the hands of the consumer, I am certain that there would be some startling and sudden changes made. I am often told that I am no worse off than the other coal users, but this does not interest me nor does it help to hold the continually increasing expenses down to where they should be.

Binghamton, N. Y. Asa P. Hyde.

Feed-Line Valve Stuck

About the most trying thing that can happen in a boiler plant is to see the water disappearing from sight in the gage-glasses and have the feed pump balk.

I had such an experience in a large plant some years ago. We had three duplex reciprocating pumps of the ordinary type. It so happened that two of these were out of service for repairs. As the check valves on the boiler-feed lines did not hold very good, it was the custom to close the discharge valve on the pump whenever it was shut down. After the pump was slowly started and had built up sufficient pressure, the valve in the feed line was opened and no trouble was experienced in forcing the water into the boilers.

On the occasion referred to, however, a green water tender started the pump, letting it run a little too long, and such a pressure was built up in the discharge deck and pipe line that the line valve, which was of the gate type and worn, could not be opened. It was not until the customary fright had been passed through that I hit upon the true reason as to why the pump would not put water in the boilers. Closing the pump throttle and releasing the pressure in the water end, the discharge line was readily cleared by opening the valve and we got water going into the boiler just in the nick of time.

Philadelphia, Penn. Edward T. Binns.

Automatic Gage-Glass Fittings

In connection with the inquiry as to objections to the use of automatic gage-glass fittings and the answer given on page 603, in the issue of Oct. 24, 1916, I would suggest that there are fittings in extensive use that are even less liable to clogging than the ordinary plain fitting and are self-clearing of any substance that will pass through a ⅜-in. globe valve used as a drain, the balls lying in pockets in the channel until there is a rush of pressure through either or both top and bottom connections. The top and bottom fittings may be blown simultaneously or independently through the regular drain without disturbing either ball, provided the glass is normally in place, but the breakage of a glass is accompanied by a loud report, although there is practically no escape of steam or water because of the prompt action of the automatics. The attendant does not have to exercise any special care other than that required for any ordinary gage-glass fitting.

Some sixty sets with which I am familiar, installed during the last 2½ years, have given entire satisfaction and not a single report has come of clogging, false water level or failure to act. B. A. Costello.

Olongapo, P. I.

[Our correspondent evidently believes that the restrictions of the Massachusetts Boiler Rules and the A. S. M. E. Boiler Code are too stringent in providing that "No water glass connection shall be fitted with an automatic shut-off valve."—Editor.]

Inquiries of General Interest

Obtaining Length of Indicator Diagrams—In measuring the length of indicator diagrams for determining the average height, is it not sufficient to take the length of the atmospheric line? H. M.

The atmospheric line may be longer or shorter than the diagram and, as other measurements are made with respect to the actual diagram, the true length should be taken as the distance between the centers of lines drawn perpendicular to the atmospheric line and tangent to the extremities of the diagram.

Effect of Inside Lap on D Slide Valve—What results from increasing the inside lap of a D slide valve? M. A. H.

The term inside lap refers to the amount the valve extends beyond the exhaust port toward the center of the valve when the valve is centrally over the ports. Therefore the effect of inside lap is to open the exhaust port later, with later release of the steam after expansion, and to close the exhaust port earlier, resulting in earlier and higher compression of the exhaust.

Delta- and Star-Connected Transformers in Parallel—Two groups of three transformers, each have their primaries connected in delta and to the same bus, and the secondaries of one group are connected star and the other delta. The secondary voltage of each group is the same. Can the transformers be connected in parallel on the secondary side? C. C. L.

They cannot be so connected because the vector sum of the voltages of the star-connected group will give a terminal voltage that is out of phase with that of the delta-connected group.

Three-Phase Power Measurements—Can a watt-hour meter be connected in a tie-line between the busbars of two three-phase power plants, where the power may be delivered from either plant, so as to measure the power supplied from one of the plants? W. E.

It will be necessary to equip the shaft of the wattmeter with a suitable pawl and ratchet to prevent the meter from reversing when the power reverses. Meters can be provided with pawls and ratchets that will cause practically no drag on the rotating element when turning in one direction, but will prevent them from reversing.

Impregnating Coils with an Insulating Compound—A large number of the coils used in electrical equipment are impregnated with an insulating compound after they are wound. How is this accomplished? A. T. B.

After the coils are wound and insulated with a plain cloth tape, they are placed in an air-tight tank, after which the air is exhausted and the tank heated with steam coils. This thoroughly dries all the moisture out of the insulation on the coil. When the drying process is completed, a liquid insulating compound is admitted into the tank and pressure is applied to force it into the openings between the windings, making a weatherproof insulation when the compound hardens.

Elliptical Patch Stronger Than Round One—What is the advantage of making a boiler patch oblong with the greater length across the boiler in place of round? L. L.

In a cylindrical shell subjected to internal pressure, the stress normal to a longitudinal cross-section is twice that of a transverse section and the stresses resolved normal to a diagonal will be less per unit of length of joint than on a longitudinal section. Hence an inclined joint need not have as high an efficiency as a joint arranged longitudinally. With an elliptical or oblong form of patch placed with the greater length around the shell, nearly all of the joint has greater inclination to the axis of the boiler than when the joint is circular, and the same type of riveted joint is more effective in resisting a given boiler pressure.

Approximate Tests of Crankshaft Alignment—What is a quick method of determining if an engine crankshaft is approximately level and is square with the center line of the cylinder? J. P. L.

Turn the shaft to bring the crankpin in its highest position and adjust a plumb line so it nearly touches a point on the end of the crankpin. Then turn the shaft to bring the center of the crankpin approximately under the center of the shaft. If the shaft is level, the point referred to will be the same distance from the plumb line for both positions of the crank. For determining whether the shaft is approximately at right angles with the center line of the cylinder, draw a line through the center of the cylinder or near the cylinder, vertically over the cylinder center line, so it will pass as nearly as possible through the center line of the shaft. With the crankpin uncovered, turn the crank forward until the side of the crankpin just touches the line; mark the point and then turn the crank backward until the other side of the crankpin just touches the line. If the shaft is square with the cylinder center line, the points of crankpin coming in contact with the line will be the same distance from a turned-up shoulder on the pin, or from the end of the pin.

Quantity of Water Contained by Boiler—How many gallons of water will be required to fill a horizontal return-tubular boiler 72 in. diameter by 18 ft. long, containing seventy 4-in. tubes, with the water level within 18 in. of the top of the shell? F. R. J.

The cross-sectional area of the space above the water line, neglecting braces, may be found by the formula for finding the area of a circular segment, namely:

$$\text{Area of segment} = \frac{4H^2}{3}\sqrt{\frac{2R}{H} - 0.608}$$

in which H = the height of segment and R = the radius, and by substitution,

$$\text{Area} = \frac{4 \times (18)^2}{3}\sqrt{\frac{2 \times 36}{18} - 0.608} = 796 \text{ sq.in.}$$

The cross-sectional area of the tubes would be $4 \times 4 \times 0.7854 \times 70 = 879.6$ sq.in., and as the gross cross-sectional area of the boiler is $72 \times 72 \times 0.7854 = 4071.5$ sq.in., the net cross-sectional area of the space occupied by the water would be $4071.5 - (796 + 879.6) = 2395.9$ sq.in., and to fill the space would require $(2395.9 \times 18 \times 12) \div 231 = 2240.3$ gal. of water.

Determining Point of Cutoff Without Indicator—How can the point of cutoff of an engine be determined without applying a steam-engine indicator? W. L.

Without reference to an indicator diagram made by the engine, determination of the point of cutoff is laborious and uncertain. To approximately determine the fraction of stroke at which cutoff occurs on a Corliss engine, mark the height of the governor collar when the engine is in operation and, after bringing the engine to rest on either center, make a mark on the crosshead corresponding with one made on the guides. Then with the governor held in the marked position, turn the engine forward by hand until the steam valve becomes released by the cutoff mechanism and make a mark on the guides corresponding with the previously made mark on the crosshead. The distance between the marks made on the guide should be equal to the travel of the piston from the beginning of the stroke to the point of cutting off. Next turn the engine until the crank is on the other dead-center and make another mark on the guide to correspond with the mark on the crosshead. The total length of stroke will be equal to the distance between the first and last marks, and the point of cutoff or fraction of stroke at which cutoff occurs would be the amount of travel completed at cutoff, divided by the length of stroke.

When the engine has a shaft governor, some means must be employed to gage the position of the governor while the engine is running and of afterward holding the governor in the same position for ascertaining the point of stroke at which the steam valve closes. With any form of fixed cutoff, as with an ordinary D-slide valve, the point of stroke at which cutoff takes place may be located on the guide with reference to a mark on the crosshead by turning the engine over until the steam valve is observed or from measurements is known to be just closed.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Refrigeration Insulation on Shipboard

In a paper before the recent annual meeting of the Society of Naval Architects and Marine Engineers, Robert F. Massa points out that refrigerators constructed by cementing cork sheets against concrete floors, walls and ceilings with wooden strips set in cork, the cork being applied in two layers each 2 in. thick, the second layer secured to the first by cement and strips of wood, the inner lining of the refrigerator being of white porcelain enameled sheets of steel, suffered much deterioration due to moisture. It was found that the insulation, particularly in the lower part of the refrigerator, was water-soaked and that the steel had become almost completely rotted out, while the wood strips holding the metal in place had rotted away. The moisture had worked down through the floor and was getting into the room below. The real cause of the trouble seems to be that it is not possible to fit the enameled sheets close enough to the cork to do away with air pockets, which with temperature variations allow interchanges of air with the outside, depositing moisture. The method of correcting the trouble consisted in removing all defective insulation, replacing it with pure cork sheets set in portland cement, using two layers of 2-in. sheets as before, and then finishing the inside of the refrigerator with cement with rounded or coved corners (see Fig. 1).

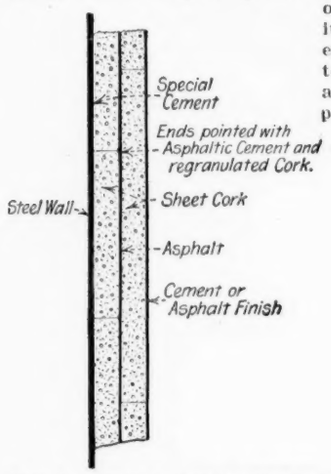


FIG. 1. INSULATION ON STEEL WALL

The author suggests that one way of overcoming the cracking of the cement coats is to give the cork a skim coat of cement, then bed into this either a sheet of expanded metal or wire mesh of some kind and then apply a final coat of cement. The writer has observed that in some insulations the cork had not been sufficiently pressed previous to baking. This cork was not as dense as it should have been and had not the mechanical strength of the other cork forming the insulation. More or less air spaces are left in the cork in which there is a tendency for moisture to penetrate, and where the temperature is very low this moisture freezes and pries the sheets of cork apart.

The writer gave it as his opinion that there is only one practical way to make a tight refrigerator door and that is to have a plain surface come up against a plain surface with a flexible gasket between, as shown in Fig. 2.

The best arrangement of cooling surface in the refrigerator is to place it either in a loft above the box—that is, above the storage compartment—or in a space alongside of this compartment with ample air passages to permit the circulation of the air between the two compartments. The force that causes the circulation of air in a refrigerator is extremely minute, being only the difference of weight between the air in the coil compartment and that in the same height of the food-storage compartment. If there is a difference of even say 15 deg. in the temperature between the two compartments, the excess weight in the one over the other is obviously extremely slight. Fig. 3 shows a section through the refrigerator which was 8 ft. wide and 6 ft. high. The cooling surface was located in the middle of the refrigerator with a plate on each side of it, and the passages for the air were identically the same on both sides, except that the space leading from the storage compartment to the coil surface at

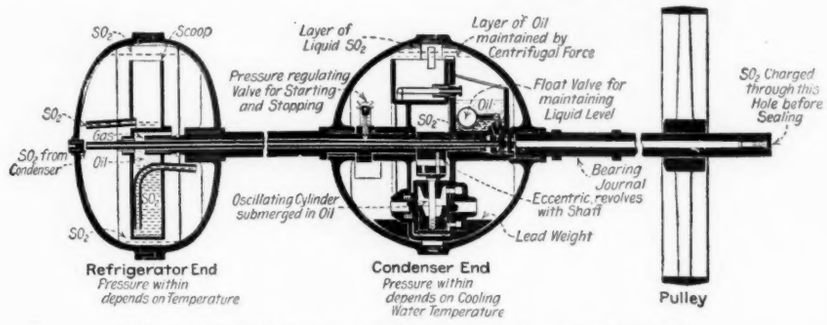


FIG. 4. SECTION OF AUDIFFREN-SINGRUN MACHINE

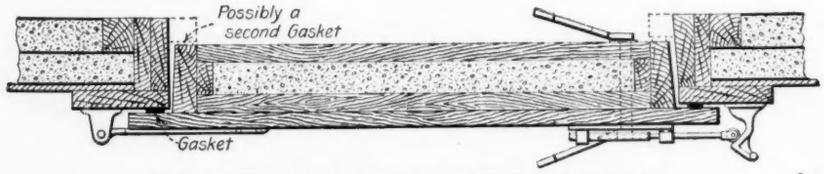


FIG. 2. TYPE OF DOOR APPROVED BY AUTHOR

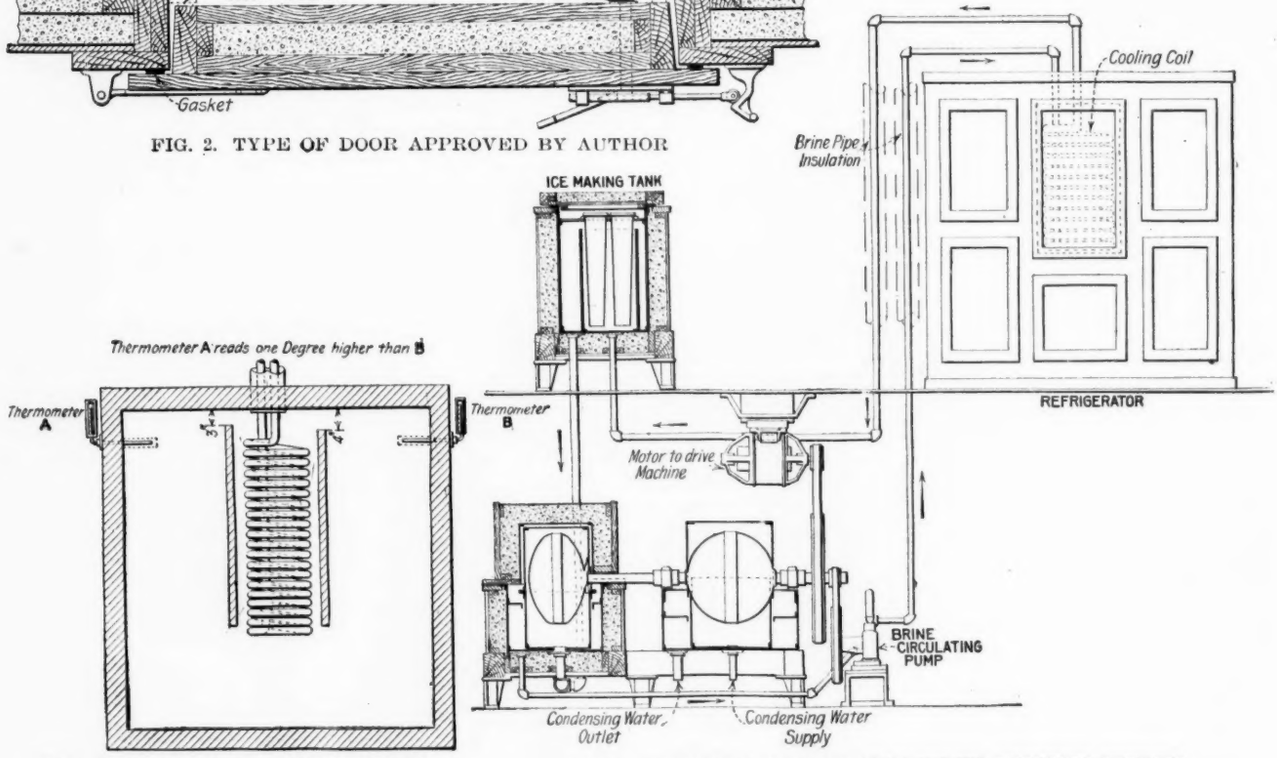


FIG. 3. SECTION OF REFRIGERATOR

FIG. 5. USUAL LAYOUT OF AUDIFFREN-SINGRUN SYSTEM

the left was 3 in. and that at the right was 4 in. The difference of one inch in this dimension made a difference in the temperatures observed at the points marked A and B of 1 deg. throughout a week's test.

The writer gave a brief description of the Audiffren-Singrun refrigerating machine which will likely interest our readers: In this machine the problem of a stuffing-box is met by closing all the working parts of a machine within a hermetically sealed drum. Referring to the sectional view, Fig. 4, the machine consists of a shaft with a pulley at one end, a drum at the other, and a second drum at the middle of the shaft. The machine is carried in two bearings, one on either side of the central drum and revolves with the central drum in contact with flowing water. The compressor, which is reduced to its simplest element because of its peculiar situation, hangs loose on the shaft inside the condenser drum, and is held in position by means of a counterweight.

A dumbbell is sent out from the factory completely charged and ready to operate. The air is entirely exhausted, and a charge of sulphur dioxide and a pure neutral oil is admitted, after which the machine is hermetically sealed. The working parts are thus constantly lubricated, and the pressure in the condenser is constantly forcing oil between the working surfaces of the compressor. Oxidation of the lubricating oil cannot occur as there is no oxygen present. It is impossible to draw air into the machine because the dumbbell is hermetically sealed. No dust can get access to the working parts, and as a consequence, the wear on the machine is reduced to a minimum.

The operation is undoubtedly clear from an inspection of the drawing, except that the devices that are provided in the cold end of the machine for the return of lubricants from this end to the condenser end are not shown, nor the means for keeping the inner surfaces at the cold end of the machine thoroughly wet with the refrigerant. The usual layout with this machine is as shown in Fig. 5.

Planning the Power-House Work

At a meeting of the Taylor Society last December, W. N. Polakov presented a paper on "Planning the Power-House Work." The paper was recently published in the Taylor Society "Bulletin," Hanover, N. H., and outlines the main functions of an organization capable of planning the power-plant work, so as to predetermine the desirable results. The author points out that the most precise knowledge of what each man and each machine can do and the most eager desire to attain the same are of no avail unless the human forces are directed in accordance with the plans consistent in every detail with all available knowledge.

The elements of such planning work are: Securing the knowledge, making the knowledge available, providing conditions which make this knowledge applicable, and observing whether the proper use is made of this knowledge. Whenever any one of these elements is not lived up to, the plant management is haphazard and the automatic penalty is an increase in the operating cost of from 10 to 40 per cent.

The planning work does not receive proper consideration in the majority of power plants. It is left to the resourcefulness of individual employees, who are often unaided by the most elementary instruments and seldom possess the time to carry on investigations and, if they did, are unqualified for scientific research work. The proper application of knowledge is a functional organization of foremanship. In most cases consideration, if given at all to the results obtained, is in the last count; namely, what the actual costs were, without due reference to what they might have been under proper consideration.

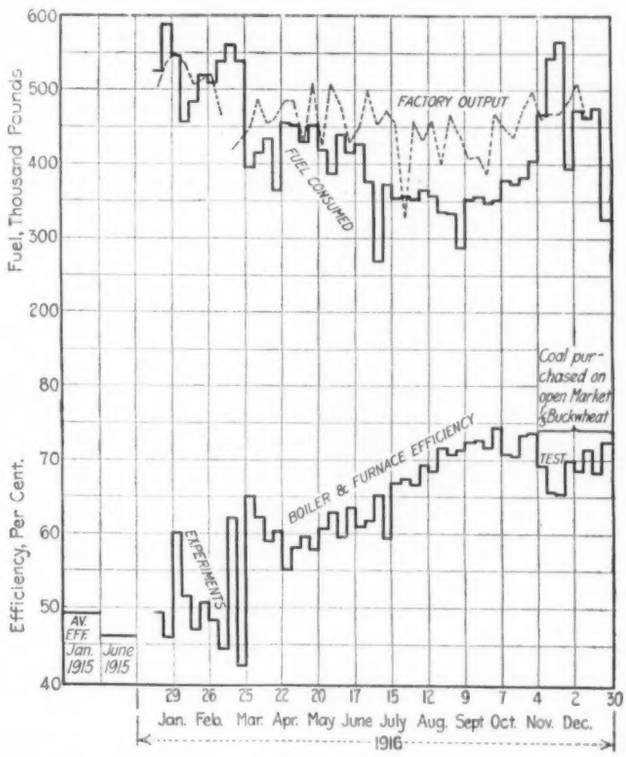
The application of the proper managerial principles in almost every power plant will materially reduce operating costs, increase the security of service, stabilize the expenses and greatly improve the relations between the management and the employees. The accompanying set of curves shows what was accomplished in a small industrial plant, consisting of 10 boilers for supplying steam for heating and manufacturing purposes, by the application of the proper principles to planning and executing the power-plant work. From a study of the curve showing the factory output, it is evident that the reduction in coal consumption was due to improved boiler efficiency, since the factory output remained about the same during the year. The curves also indicate that the coal consumption varies in approximately inverse proportion to the boiler and furnace efficiency.

Another point of interest in connection with these curves is that beginning the second week of November the supply of bituminous coal delivered by contract came to an end, and from that time on the coal was purchased on the open market; a mixture of two parts bituminous and one part anthracite coal was used. During the third and fourth weeks of November tests were conducted to find out the best method of firing, cleaning, etc. When the new routine was standardized, the average efficiency with the poorer coal reached the 70-per cent. mark. This incident points out that 70-per cent. boiler efficiency in this case is more desirable than 72 because the difference in the price of the two grades of coal is sufficient to more than offset the drop in efficiency.

The necessary instruments to obtain these results consisted of one indicating pyrometer for flue temperatures, 10 thermocouples, one covered-type differential-draft gage, one duplex standard thermometer with two records and one inclosed chart, one recording steam-pressure gage and 10 steam flowmeters, one for each boiler. The total cost was approximately $1300. All the instruments were mounted on a central board and the boilers put in charge of a combustion engineer.

To determine in advance what results may actually be obtained from the operation of a plant appears to many to be a waste of time. However, when this has been done, the knowledge has led to efforts being made to secure the results for which the plant was designed.

The securing of the data showing what a plant can do must be accomplished by scientific analysis and thorough



RESULTS OBTAINED BY PROPERLY PLANNING THE WORK IN A SMALL INDUSTRIAL-PLANT BOILER ROOM

research work. There are three distinct steps: (1) Investigation into what conditions result in the highest operating efficiency of each separate unit of equipment; (2) experimentation leading to the discovery of how the best conditions may be secured and maintained at will; (3) coördination of thus found practice in a manner that will show what is the most advantageous inter-relation of these conditions, and the resulting individual efficiency from the following aspects: Security of operation, welfare of employees, cost of operation, cost of maintenance and idle overhead expenses. This research work is a logical prerequisite to the proper management of any plant.

The literature written on methods of power-plant testing totally ignores the main point—what the tests are made for. Time and expense of testing made by untrained persons is a pure waste, and often serious harm is done for the future by wrong conclusions derived. Tests that are made without keeping complete records of all conditions should not be run at all. Only complete and continuous records are useful and dependable. Tests that are not augmented and supplemented by time and motion study of the men attending the unit under test are of limited value, inasmuch as the most important factor is thus overlooked—whether under everyday service it is feasible for men to duplicate test conditions.

Test data that are not carefully and exhaustively worked out are useless. Again, unless they are analyzed immediately

and checked several times by repeated tests to ascertain if the results obtained can be duplicated at will, they are of no practical value.

The complete knowledge of what is the correct thing to do and the right way to do it will not produce results unless the men are taught to perform their duties in the proper manner. This can be done successfully only by offering the employees an incentive. There are several methods of stimulating the employees to do better work, which may be roughly classed as profit-sharing plans, premium schemes, rewarding individual efforts and task with bonus.

Profit sharing is based on the assumption that the employees by their work contribute to the success of the enterprise in securing profits. This would be entirely correct if the employees were given the opportunity to control all functions of management, fix the salaries of directors, direct purchases and sales and have the right of veto in all financial transactions. But as conditions now exist, profit sharing with the employees is but a matter of gift for the purpose of keeping peace with the owners' conscience or in anticipation that the men will rebel when they learn how small their wages are compared with the profits derived from their efforts.

Premium plans as worked out in power plants are very unsatisfactory. The common error of all these attempts is that the final cost of operation is considered as a basis for the award or denial of the premiums. Yet it is perfectly clear that the cost depends not only on the excellence of work, but equally, if not in a much larger degree, upon the method and means of upkeep, cost of fuel and supply and its quality, quantity of output, load factor, use factor, etc. None of these factors is under the control of the power-plant employee.

The rewarding of individual effort is perhaps the most unscientific of all. Where this method is applied, one or more isolated phenomena, like high CO_2 in flue gases, low carbon in ashes, etc., are chosen, and the men accomplishing the best results in this direction are rewarded, while overlooking the fact that no one of these factors indicates the perfection of operation of the whole plant.

As opposed to the three foregoing methods the assignment of a well-defined task to each member of an organization is advocated. The setting of a task presupposes the complete and detailed knowledge of each and every process performed in the plant, including reliable information as to what each unit of equipment can do and what are the conditions producing the desired results. Results necessarily follow conditions; therefore, the task really consists in maintaining conditions as prescribed, not in attaining results, inasmuch as we are assured of these if all requirements are complied with. The bonus is granted or not, according as the prescribed conditions are maintained.

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Educational Visits to Plants

The Educational Committee of Brooklyn No. 8, N. A. S. E., when presenting the engineering playlet, "The Value of Recording Instruments," over two years ago, found that many of the members were not engaged in plants having the various instruments shown on the screen, and many expressed a desire for an opportunity to see the "dope machines" hooked up so they could "see" for themselves. The committee therefore decided to follow the practice of engineering schools in combining plant visits with lectures. The immediate results were surprising; the attendance at lectures showed an increase of over 100 per cent., and the attendance on pilgrimages in search of "wisdom" became greater with each succeeding visit—from 55 at first to 235 on some of the latest visits, and the 500 mark is in sight judging by the increasing numbers.

The lectures and visits are now a combined feature, being participated in by Nos. 8, 15, 27, 41 and 57. The lectures are delivered at the Operating Engineers' Building, 125 South Elliott Place, Brooklyn, each alternate Thursday evening, and the visits are made Friday evenings.

A few of the plants visited this season are: The Equitable Life, Western Union Building, Edison Waterside Station, Singer Building, Hotels Manhattan and Claridge, the Belnord Apartments, Consolidated Card Co., the McGraw-Hill Publishing Co. and the Robert Gair Co. Those booked for the season will extend well into the month of May. The next is to be to the Fifty-ninth Street Power Station of the Interborough Transit Co., arranged for by Willis Lawrence.

Much praise is due these men who leave their home comforts after a hard day's work that they may better prepare themselves to meet the rapid changes in their vocations.

The Educational Committee wishes to announce that all engineers are invited to attend the lectures and visits and the regular invitations will be forwarded upon request by addressing John B. McGowan, chairman, Operating Engineers' Building, 125 South Elliott Place, Brooklyn, N. Y.

Runaway Engine Flywheel Bursts

On Mar. 7 the flywheel on a 16 x 20-in. Wheland engine in a planing mill near Tuscaloosa, Ala., burst, killing one man and doing considerable damage to the buildings and machinery. As there was no one in the engine shed when the engine began to race, the primary cause of the accident is unknown, but it is assumed that the governor belt broke and the safety stop failed to act, the broken governor belt being found after the accident. Before the attendant could reach the throttle the great speed had thrown off nearly all the machine belts, and the wheel burst. Parts of the wheel were thrown about one-eighth of a mile.

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Development of Electric Service

Additional information illustrating the development of electric service in the districts of the subsidiary companies of the General Gas and Electric Co. is brought out in the accompanying tables, which show the revenues per capita of population served, the connected load per consumer and the number of inhabitants per consumer in each district served.

Table I shows the revenue per capita in each district served in 1916, as compared with 1915. In nearly all instances there has been growth. This is in keeping with the general growth of the industry in 1916:

TABLE I. REVENUE PER CAPITA

	1916	1915	Increase per Cent.
Pennsylvania Utilities Co.	$7.92	$6.77	17.0
Eastern Penn. Pr. Co. of N. J.	3.12	3.97	21.4†
Port Clinton El. Lt. and Pr. Co.	6.64	5.80	14.5
Northwestern Ohio Ry. and Pr. Co.	12.85	10.58	21.5
Binghamton Lt., Ht. and Pr. Co.	4.76	4.17	14.1
Sandusky Gas and Electric Co.	7.94	6.85	16.0
Rutland Ry., Lt. and Pr. Co.	5.39	4.94	9.1
Western Vermont Pr. and Lt. Co.	6.35	5.50	15.5
Sayre Electric Co.	4.30	4.11	4.6
New Jersey Pr. and Lt. Co.	4.11*	.....	....

* Ten months' record. † Decrease.

Table II shows the connected load, in kilowatts, per consumer. Where a reduction is shown, it indicates that the development of commercial business was greater than that of power, an increase indicating the greater development on the power side. The variation in volume of connected load may be taken to indicate the character of the present business—the greater the load per consumer the greater the volume of industrial power:

TABLE II. CONNECTED KILOWATTS PER CONSUMER

	1916	1915	Decrease per Cent.
Pennsylvania Utilities Co.	2.54	2.70	5.9
Eastern Penn. Pr. Co. of N. J.	2.21	2.35	6.0
Port Clinton El. Lt. and Pr. Co.	1.32	1.29	2.3*
Northwestern Ohio Ry. and Pr. Co.	9.20	10.20	9.8
Binghamton Lt., Ht. and Pr. Co.	1.70	1.87	9.1
Sandusky Gas and Electric Co.	2.55	2.65	3.8
Rutland Ry., Lt. and Pr. Co.	2.22	2.26	1.7
Western Vermont Pr. and Lt. Co.	4.15	3.28	26.5*
Sayre Electric Co.	1.71	1.86	8.1
New Jersey Pr. and Lt. Co.	2.24	.....	....

* Increase.

Table III, showing the relation of consumers to population in the several districts served, gives an idea of the density of commercial service. A decrease in this table indicates a growth in the number of consumers as compared with 1915:

TABLE III. NUMBER OF PEOPLE PER CONSUMER

	1916	1915	Decrease per Cent.
Pennsylvania Utilities Co.	12.0	13.3	9.8
Eastern Penn. Pr. Co. of N. J.	38.8	17.0	128.5*
Port Clinton El. Lt. and Pr. Co.	4.5	5.0	10.0
Northwestern Ohio Ry. and Pr. Co.	12.9	14.9	13.4
Binghamton Lt. Ht. and Power Co.	12.3	14.9	17.5
Sandusky Gas and Electric Co.	8.8	9.1	3.3
Rutland Ry., Lt. and Pr. Co.	5.4	4.9	10.2*
Western Vermont Pr. and Lt. Co.	12.9	14.0	7.9
Sayre Electric Co.	10.1	11.2	9.8
New Jersey Pr. and Lt. Co.	14.1	....	....

* Increase.

In combination the three tables serve to indicate not only the present state of development, but the possibilities of future development and in what class, commercial or industrial power, this development may be looked for. For example: The Binghamton district is shown to have a low revenue per capita; its connected load is small, indicating undeveloped industrial business; and its relation of population to consumers is high, indicating possible further commercial development. Again, the Northwestern Ohio district shows a large revenue per capita, obtains that through large industrial loads, but its density of commercial development is about the same as that of Binghamton.

Engineering Societies' New Librarian

Harrison W. Craver, who has been chief librarian of the Carnegie Library, of Pittsburgh, since 1908, has tendered his resignation, to take effect Apr. 1, and accepted the position of director of the library of the United Engineering Societies, New York, believed to be the largest engineering library in the world, with approximately 150,000 volumes on technological subjects on its shelves. Mr. Craver has been associated with the Carnegie Library for about 17 years, and during his administration there has been a steady development in that library. The technological branch, which is now one of the most comprehensive in any of the general public libraries of the country and which covers exhaustively nearly every industry in the vicinity of Pittsburgh, is the result of his foresight and understanding of a public need and his energetic effort to supply it. His efficiency in handling this branch of the work was due as much to his previous experience as chemist for steel companies (Leechburg and Pittsburgh, Penn., and Graham, Va.) as to his ability as a librarian.

MISCELLANEOUS NEWS

A Steam-Engine Flywheel Burst at the Fox Paper Co.'s plant, Lockland, Ohio, late on the night of Mar. 9, seriously injuring the night engineer and wrecking the engine room. The loss is estimated at more than $5000.

Great Northern Railway To Electrify—It has been announced that the Great Northern Ry. has already begun the construction of transmission lines for the complete electrification of its rail system west of the Idaho State line. The initial project is to cost $20,000,000 and includes electrifying 500 miles of track and the construction of a 150,000-hp. hydroelectric plant on the Chelan River to operate the company's lines between Spokane and Seattle.

A $6,000,000 Hydro-Electric Plant at Wateree, S. C.—The Southern Power Co. has let a contract to the Hardaway Contracting Co. for the immediate erection of a large hydroelectric power plant on the Wateree River, six miles above Camden, S. C. The new plant, which will be known as "Wateree," will develop 100,000 hp. and connect with the company's six other plants located upon the same river. The dam here will be a half-mile long and will impound water to drive five units, each with a capacity of 20,000 hp. It will probably be completed by November, 1918, and thus care for the increasing demands for cheap power.

ENGINEERING AFFAIRS

The Detroit Engineering Society will hold a meeting on Friday evening, Apr. 6. Prof. W. K. Hatt, of Purdue University, will speak on "Reinforced Concrete."

The American Chemical Society will hold its fifty-fourth general meeting in Kansas City, Mo., Apr. 10-14, with headquarters at the Hotel Muehlebach. An interesting program is being arranged, and symposiums on petroleum and natural gas and on zinc will be features of the meeting.

The Combined Educational Committees of Brooklyn N. A. S. E. have arranged for a series of lectures, the first to be given on Thursday evening, Mar. 29, at the Operating Engineers' Building, 125 South Elliott Place, by Lewis Jones, associate editor of "Power," on "The Manufacture of Iron and Steel," illustrated with lantern slides.

The Steel Treating Research Club will hold the following meetings: On Tuesday evening, Apr. 3, W. M. Corse and G. F. Comstock will present a paper on "Metallic Alloys with Special Reference to Brass and Bronze," illustrated with slides; on Friday evening, Apr. 13, E. F. Lake will address the club on "Failures of the Carbonizing Process."

The American Society of Steam Boiler Inspectors of New York City will hold its regular meeting in the Engineering Societies Building, 29 West 39th St., New York City, on Mar. 30, at 8 p.m. J. A. Kinkead will give a talk on steel content in relation to tensile strength and ductility, and Michael Fogarty will discuss the Boiler Code in New York State.

Elizabeth Association No. 14, N. A. S. E., of New Jersey, held its third annual smoker at the Hippodrome on Wednesday, Mar. 14. The large hall was comfortably filled and a good vaudeville entertainment was enjoyed. Refreshments were served at intervals. John J. Callahan was the master of ceremonies and James S. Heath chairman of the arrangement committee.

Brooklyn Association No. 54, N. A. S. E., held its fifteenth anniversary on the evening of Mar. 14, at the Operating Engineers' Building, 125 South Elliott Place, Brooklyn, N. Y. The occasion brought out most of the old members, and many visitors were present. There was a pleasing entertainment, at the close of which good things to eat, drink and smoke were served. Amos F. Thiergardt, Charles Schabacker, John Geissler, Frederick Gross and William Jobson comprised the arrangement committee.

The National Association of Manufacturers will hold a meeting in New York City on Thursday, Mar. 29, at 2 o'clock, at the Waldorf-Astoria (Astor Gallery). Hon. José A. Del Campo F., commercial delegate of the Chilean Government, will give an illustrated lecture. Manufacturers of machinery, engines and motors should be specially interested in this lecture, as the pictures to be shown have been selected with the view of illustrating Chile's present industrial development and immediate future needs in this direction. Oil, coal and waterfalls are available for power development. Admission will be by ticket only, which may be obtained from the association offices.

The Southwestern Society of Engineers has recently been formed to afford engineers in western Texas, New Mexico and Arizona the opportunity of getting acquainted and of coöperating to their mutual benefit. The new society has no local sections at present, but it is probable that as it grows stronger sections will be formed in the larger cities where enough men are available. The constitution, which has just been drafted, states that the objects of the society are the professional improvement of its members, the encouragement of social intercourse among engineers, the advancement of engineering knowledge, education and practice and the maintenance of a high professional standard among its members. There are three classes of membership—full, associate and affiliated. The constitution provides for semiannual conventions, the first of which was held at El Paso, Tex., Mar. 8-10. Prof. A. F. Barnes, dean of engineering at the New Mexico College of Agriculture and Mechanic Arts, State College, New Mexico, is secretary and organizer of this society.

The Alumni Class of the New York School of Heating and Ventilation held its fifth annual dinner on Mar. 12. The main dining room of the Building Trades Employers' Association, 30 West 33rd St., was tastefully decorated, and at the tables were seated fully 150 members and guests. This is a big increase over the first dinner, when there were 22 present. The addresses were brief, bright and interesting. Frank Chew, editor of the "Metal Worker," paid a tribute to Charles A. Fuller, the founder and tutor of the school, when he said that Mr. Fuller had done more for the advancement of heating and ventilation than anyone he knew. Dr. M. W. Franklin told of the improvement in the heating and ventilation of factories, shops and schools. Charles A. Fuller thanked his pupils for their close attention in the classroom and said that with their aid he hoped that the class next season would be the largest ever. Walter Klocksin and R. A. Wolf spoke of the first and second year classes respectively. Jack Armour recited and told stories. Songs were sung at intervals by Ross Fowler. John W. Schmidt furnished the orchestra. E. A. Kingsley made a snappy toastmaster. The committee in charge was given a vote of thanks for the excellent arrangement of the dinner.

BUSINESS NOTES

The Sarco Co., Inc., has opened a branch office in Buffalo, at 325 Ellicott Square, with F. D. Harger in charge.

M. H. Detrick Co., Inc., announces its arrangement with L. S. Shaw & Co., of Detroit, Mich., to represent it in southern Michigan, with L. S. Shaw as district sales manager.

The Bacharach Industrial Instrument Co., of Pittsburgh, Penn., has moved into more spacious quarters at 422 First Ave., where it can the more readily take care of its increasing business.

The Ashton Valve Co. announces the removal of its main office in Boston to its factory at 161-179 First St., Cambridge, "C," where more commodious quarters have been provided to handle its growing business.

THE COAL MARKET

Boston—Current quotations per gross ton delivered alongside Boston points as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Mar. 24, 1917	One Year Ago	Mar. 24, 1917	One Year Ago
Buckwheat	$3.40@4.40	$3.05@3.20	$5.50@5.75	$3.25@3.50
Rice	.....	2 50@2.65	.....	2.70@2.95
Boiler	2.75@3.75	.....	.....	.....
Barley	2.65@3.65	2.20@2 35	.....	2.35@2.60

BITUMINOUS

Prices per gross ton for Boston delivery are as follows:

	F.o.b. Mines*		Alongside Boston†	
	Mar. 24, 1917	One Year Ago	Mar. 24, 1917	One Year Ago
Clearfields	$4.75@5.60	$1.35@1.75	$8.90@9.50	$4.25@5.00
Cambrias and Somersets	5.25@5.60	1.55@2.00	9.15@9.75	4.60@5.40

Pocahontas and New River, f.o.b. Hampton Roads is $7@7.25, as compared with $2.80@2.85 a year ago; on cars Boston price is $11.50@12.50 against $5.25@6.00 a year ago.

*All-rail rate to Boston is $2 60. †Water coal.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Mar. 24, 1917	One Year Ago	Mar. 24, 1917	One Year Ago
Buckwheat	$2.75	$2.75	$5.25@5.50	$3.50@4.00
Rice	2.20	2.25	4.50@4.75	2.65@2.75
Barley	1.95	1.75	4.00@4.50	2.30@2.40

BITUMINOUS

	South Amboy	Port Reading	Mine Price
Clearfield	$7.00@7.50	$7.00@7.50	$5.25@5.50
South Forks	7.50@7.75	.....	5.50@5.75
Nanty Glo	7.50@7.75	.....	5.50@5.75
Somerset	7.00@7.25	7.00@7.25	5.00@5.25
Quehamoning	7.50@7.75	7.50@7.75	5.25@5.50

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The freight rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Mar. 24, 1917	One Year Ago	Mar. 24, 1917	One Year Ago
Buckwheat	$2.50	$1.55	$3 40	$2.30
Rice	2.10	.90	3.00	1.80
Boiler	1.95	....	3.15	....
Barley	1.85	.55	2.05	1.30

Pittsburgh—Price of steam coal per net ton f.o.b. mine, Pittsburgh district:

	Mar. 24, 1917	One Yeag Ago
Slack	$3.75	$1.10@1.15
Mine-run	3.75@4.00	1.15@1.30
¾-in.	3.75@4.00	1.25@1.40

Add 40c. per ton for freight charge to Pittsburgh.

Chicago—Current price per net ton f.o.b. mines are as follows:

	Williamson and Franklin Counties	Saline and Harrisburg	West Virginia Smokeless	Springfield	Clinton and Sullivan Counties
Steam Lump	.....	$3.50@3.75	$4.75@5.00	$2.75@3.25	$3.00@3.50
Lump	$3.75@4.00	3.75@4.00	5.00@5.25	3.00@3.25	3.25@3.75
Egg	3.75@4.00	3.75@4.00	4.75@5.00	2.75@3.25	3.00@3.50
Nut	.....	3.50@3.75	.....	3.00@3.25	3.00@3.50
No. 1 nut	3.75@4.00	.....	.....	.....	.....
No. 2 nut	3.75@4.00	.....	.....	.....	.....
No. 3 nut	3.50@3.75	.....	.....	.....	.....
No. 1 washed	3.75@4.00	.....	.....	.....	.....
No. 2 washed	3.75@4.00	.....	.....	.....	.....
Mine-run	3.00@3.25	2.75@3.25	4.50@4.75	2.00@2.25	2.75@3.00
Screenings	2.75@3.25	2.75@3.25	.....	2.00@2.25	2.50@3.00

Hocking lump, $4.25@4.50; splint lump, $4.00@4.25.

St. Louis—Price per net ton f.o.b. mine a year ago as compared with today are as follows:

	Williamson and Franklin Counties		Mt. Olive and Staunton		Standard	
	Mar. 24, 1917	One Year Ago	Mar. 24, 1917	One Year Ago	Mar. 24, 1917	One Year Ago
6-in. lump	$2.50@2.75	$1.50@1.75	$2.25@2.50	$1.25@1.40	$2@2.25	$1.05@1.15
2-in. lump	2.50	1.25@1.50	2.25	1.15@1.25	1.75@2	.85@1.00
Steam egg	2.50	1.25@1.50	2.25	1.15@1.25	1.75@2	.85@1.00
Mine-run	2.25@2.50	1.05@1.15	2.00	1.05@1.15	1.50@1.75	.80@ .95
No. 1 nut	2.50@2.75	1.25@1.50	2.25@2.50	1.15@1.25	2.00	.85@1.00
2-in.screen	2.25@2.50	.80@ .90	2.00	.75@ .90	1.50@1.75	.70@ .80
No. 5 washed	2.25	.80@ .90	1.85	.80@ .90	1.50	.75@ .85

Williamson-Franklin rate St. Louis, 72½c.; other rates, 57½c.

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run		Mine-Run
Pratt	$3.25@3.50	Carbon Hill	$2.75@3.00
Big Seam	2.50@3.00	Cahaba	3.25@3.50
Black Creek	3.25@3.50		

[1]Individual prices are the company circulars at which coal is sold to regular customers irrespective of market conditions. Circular prices are generally the same at the same periods of the year and are fixed according to a regular schedule.

PROPOSED CONSTRUCTION

Ark., Stephens—City will install an electric-light plant. J. R. Whaley is reported interested.

Calif., Crockett—The Great Western Power Co. is having plans prepared for a 1-story, reinforced-concrete power plant. Estimated cost, $100,000. P. W. Ham, 14 Sansome St., San Francisco, Engr.

Colo., Loveland—City will hold an election Apr. 3 to vote on $83,000 bonds to install an electric-light and power plant. G. C. Risr, City Clk.

Ga., Emerson—The Georgia Railway and Power Co., Atlanta, will construct a power station and electric transmission lines in the Emerson Dist. W. H. Smaw, Electric and Gas Bldg., Atlanta, Pur. Agt.

Ill., Montgomery—The Montgomery Hydro-Electric Power Co. has had plans prepared for a plant on the Fox River. H. A. Strauss, 111 West Monroe St., Chicago, Engr.

Ind., Gary—The Gary Heat, Light and Water Co. will construct a 40 x 40-ft. substation. Estimated cost, $12,000.

Ind., Georgetown—R. Hurst, Pekin, has been granted a franchise to install an electric-light and power plant.

Iowa, Mason City—L. Deckers & Sons has had plans prepared for a 1-story, 50 x 70-ft. boiler plant. Estimated cost, $60,000. Gardner & Lindberg, 140 South Dearborn St., Chicago, Engr.

Iowa, Nevada—The Iowa Railway and Light Co., Cedar Rapids, will construct a high-tension electric line from the plant to Dayton Lake Amusement Park to furnish electricity to the park and the farmers on the line, thence through Gilbert to Story City. J. M. Drabelle, Cedar Rapids, Ch. Elec. Engr.

Kan., Munden—City Council plans an electric-light plant. Estimated cost, $30,000.

Maine, Castine—City will install an electric-lighting system.

Mich., Bangor—The Village Council plans an election to vote on bonds to improve the electric-light plant.

Mich., Detroit—The American Brewing Co. will construct a 1-story, 47 x51-ft. boiler house. A. S. Fetters, Cary St., Secy. Mildner & Eisen, 925 Hammond Bldg., Arch., will soon receive the bids.

Minn., Rochester—City has had plans prepared for a hydro-electric plant on the Zumbro River. Estimated cost, $60,000. H. L. Cooper, 101 Park Ave., New York, Consult. Engr.

Minn., Winona—City will install an electric generating plant. W. P. Murphy, Chn. Lighting Comn.

Mo., Kansas City—The Kansas City Light and Power Co., 1500 Grand Ave., will soon receive bids for a power plant. Estimated cost, $6,0000,000. J. H. Lucas, Pres.

Mont., Livingston—City will construct an electric-light plant.

Neb., Indianola—City will hold an election on Apr. 3 to vote on $14,000 bonds to install an electric-lighting system and 12 miles of transmission line.

N. J., Trenton—The Westinghouse Lamp Co., 160 Broadway, New York, has had plans prepared for a 1-story, 50 x 100-ft. power house. Stone & Webster Engineering Corp., 147 Milk St., Boston, Engr.

N. Y., Buffalo—The East Buffalo Brewing Co., Emslie St., will construct a boiler house. J. C. Schultz, 1370 Main St., Arch.

Ohio, Cincinnati—W. Baldwin, c/o Union Distilling Co., 3rd and Race St., will soon receive bids for an addition to its power plant.

Ohio, Cleveland—The Cleveland-Sandusky Brewing Co., 1935 West 28th St., has had plans prepared for an addition to its boiler house. Estimated cost, $4000.

Okla., Mountain Park—City will install an electric-lighting system.

Okla., West Tulsa—The City Council will hold an election to vote on bonds to install an electric-lighting system.

Penn., Erie—The Erie Lighting Co., 11th and State St., has had plans prepared for a brick and reinforced-concrete power house. F. B. Hofft, Vice-Pres. Day & Zimmerman, 611 Chestnut St., Arch.

Penn., Meadville—I. O. O. F. Home will soon receive bids for an addition to its boiler room. J. W. Yard & Son, Erie, Arch.

Penn., Pottsville—The Philadelphia & Reading Coal and Coke Co., Reading Terminal, Philadelphia, will install a power plant to supply energy to its Knickerbocker mine; also a distributing system to supply the neighboring communities.

S. D., Iroquois—W. L. Gordon plans to improve its electric-light plant, including the installation of a gas engine and generator.

Tex., Columbus—E. C. Guilmartin, Mgr., Texas Motor Co., has been granted a franchise to install an electric-light plant.

Tex., Goliad—E. F. Glaise will improve the electric-light plant.

Wis., Endeavor—The Endeavor Light and Power Co. plans to install an electric transmission line to Packwaukee, a distance of 5 miles. W. H. Burwell, Mgr.

Wis., Milwaukee—The Board of Education, 10th and Prairie St., has had plans prepared for a 1-story, 26x 40-ft. boiler house. F. M. Harbach, Secy. Van Ryn & DeGelleke, Caswell Blk., Arch.

Wis., Monticelo—The Village Board plans to hold an election on Apr. 3 to vote on $12,000 bonds to install an electric-power plant.

Wyo., Burns—City will hold an election to vote on bonds to install an electric-light plant. C. C. Carlisle, Cheyenne, has been retained to prepare the plans.